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Tank Characterization Report for Single-Shell Tank 241-S-109

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U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This document summarizes information on historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-S-109, Sampling and Analyses Meet Safety Screening Objectives. This report supports requirements of Tri-Party Agreement Milestone M-44-05.

Kara M Broz 1/22/97
Release Approval Date

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Tank Characterization Report for Single-Shell Tank 241-S-109

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Project Hanford Management Contractor for the
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CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TERMS

μCi/g	microcuries per gram
μCi/L	microcuries per liter
μg	microgram
μg/g	micrograms per gram
A/C	aluminum to caustic ratio
ANOVA	analysis of variance
Btu/hr	British thermal units per hour
CEO	change engineering order
CF	concentration factor
Ci	curies
Ci/L	curies per liter
CI	confidence interval
cm	centimeter
CWR	REDOX cladding waste
CWR1	REDOX cladding waste from 1952 to 1960
DOE	U.S. Department of Energy
DQO	data quality objective
DSC	differential scanning calorimetry
EB	evaporator bottoms
ECN	engineering change notice
Ecology	Washington State Department of Ecology
FIC	Food Instrument Corporation
ft	feet
g	grams
g/cc	grams per cubic centimeter
g/L	grams per liter
g/mL	grams per milliliter
GEA	gamma energy analysis
HHF	hydrostatic head fluid
HDW	Hanford defined waste
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
J/g	joules per gram
kg	kilogram
kg/L	kilograms per liter
kgal	kilogallon
kL	kiloliter
kW	kilowatt

LIST OF TERMS (Continued)

L	liter
LANL	Los Alamos National Laboratory
LL	lower limit
LOW	liquid observation well
m	meter
M	moles per liter
mm	millimeter
mrad/hr	millirads per hour
MT	metric ton
n/a	not applicable
NR	not reviewed
PF	partitioning factor
PHMC	Project Hanford Management Contractor
PN/S	partial neutralized inventory/analytical inventory
ppm	parts per million
R	REDOX High level waste from 1952 to 1960
RCW	REDOX Coating Waste
REDOX	Reduction Oxidation facility
RPD	relative percent difference
S	analytically determined inventory
SAP	sampling and analysis plan
SMMS1	supernate mixing model for 242-S Evaporator, 1973-1976
SST	single-shell tank
S1SltCk	242-S Evaporator saltcake waste, 1973-76
TCP	tank characterization plan
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TWRS	Tank Waste Remediation System
UL	upper limit
W	watts
WSTRS	waste status and transaction record summary
wt%	weight percent

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1.0 INTRODUCTION

One major Tank Waste Remediation System (TWRS) function is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, along with other available information about a tank, are compiled and maintained in a tank characterization report (TCR). This report and its appendices serve as the TCR for single-shell tank 241-S-109. This report has the following objectives:

- Respond to technical issues associated with 241-S-109 waste using characterization data
- Provide a standard characterization of this waste in terms of a best basis inventory estimate.

The response to technical issues is summarized in Section 2.0, and the best basis inventory estimate is presented in Section 3.0. Recommendations regarding safety status and additional sampling needs are provided in Section 4.0. Supporting data and information are contained in the appendices. This report also supports the requirements of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-10.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and available historical sources. While the data quality objectives (DQOs) required that technical issues be resolved using results from recent sampling events, which are listed in Table 1-1, other information could be used to support (or challenge) applicable conclusions derived from these results. For example, analytical results presented in this report are for only the top portion of the tank. However, based on historical tank transfer data, except for a thin bottom layer of sludge, the tank is expected to consist almost entirely of one type of waste (Agnew et al. 1996a). As a result, the partial cores analyzed may represent the majority of the tank contents. Historical information for tank 241-S-109 (see Appendix A) includes surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

The recent sampling events listed in Table 1-1, as well as sample data obtained before 1989, are summarized in Appendix B along with the sampling results. The results of the 1996 sampling events, also reported in the laboratory data package (Fritts 1996), partially satisfied the data requirements specified in the tank characterization plan (TCP) for this tank (Winkelman 1996). The statistical analysis and numerical manipulation of data used in issue resolution are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-S-109 and its respective waste types is contained in Appendix E. The reports listed in Appendix E may be found in the Tank Characterization Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/date	Phase	Location	Segmentation	% Recovery	Mass (g)
Vapor sample (6/04/96)	Gas	Tank headspace, Riser 11, 6 m (20 ft) below top of riser	n/a	n/a	n/a
Push Core (6/21/96 to 7/08/96)	Solid	Risers 14 and 16	Divided samples in half (upper and lower)	Riser 14; 4 of 12 segments obtained Riser 16; 2 of 12 segments obtained Material too hard to push	829 g solid 68.8 g liquid

1.2 TANK BACKGROUND

Tank 241-S-109 is located in the 200 West Area S Tank Farm on the Hanford Site. It is the last tank in a three-tank cascade series. The tank went into service in 1952. From the fourth quarter of 1952 until the fourth quarter of 1955, Tank 241-S-109 received waste from the Reduction Oxidation (REDOX) facility through tank 241-S-108. The tank remained relatively static from 1956 to the fourth quarter of 1973. From the first quarter of 1974 until the fourth quarter of 1974, supernate was transferred to tank 241-S-102, and tank 241-S-109 was salt filled with evaporator bottoms waste and recycle streams from the 242-S Evaporator through tank 241-S-102. A jet pump was installed and pumping began in 1978. Between 1978 and 1979 partially neutralized feed liquid was jet pumped to tank 241-SY-102. Liquid waste from the tank was saltwell pumped to tank 241-AW-102 in 1985. The waste is currently classified as noncomplexed. Tank S-109 was partially interim isolated in December 1982 (Agnew et al. 1996b).

Table 1-2 presents the statistics and status of tank 241-S-109. The tank has an operating capacity of 2,870 kL (758 kgal) and presently contains 1,920 kL (507 kgal) of waste (Agnew et al. 1996b). Note that this volume is lower than Hanlon (1996) estimates, which do not include a transfer of 230 kL (61 kgal) from tank 241-S-109 in 1985.

Tank 241-S-109 is not on any Watch List (Public Law 101-510).

Table 1-2. Description and Status of Tank 241-S-109.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1950 to 1951
In-service	1952
Diameter	23 m (75 ft)
Maximum operating depth	7 m (23 ft)
Capacity	2,870 kL (758 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Noncomplexed
Total waste volume[1]	1,920 kL (507 kgal)
Sludge volume[1]	49 kL (13 kgal)
Saltcake volume[1]	1,870 kL (494 kgal)
Drainable interstitial liquid[2]	534 kL (141 kgal)
Waste surface level (September 16, 1996)	437 cm (172 in.)[1]
Temperature (January 1993 to September 1996)	12.9°C to 31.9 °C
Integrity	Sound
Watch List	None
SAMPLING DATES	
Push core sample	June 21 to July 8, 1996
Vapor sample	June 4, 1996
SERVICE STATUS	
Declared inactive	1979
Intrusion prevention	Not completed
Interim stabilized	Not completed

[1]Waste volume is estimated from Agnew et al. (1996b). The surface level measurement is low because of irregularities in the waste surface (Swaney 1993).

[2]Hanlon (1996)

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2.0 RESPONSE TO TECHNICAL ISSUES

The following technical issues have been identified for tank 241-S-109 (Brown et al. 1996).

Safety screening:

- Does the waste pose or contribute to any recognized potential safety problems?

Historical model:

- Is the waste inventory generated by a model based on process knowledge and historical information (Agnew et al. 1996b) representative of the current tank waste inventory?

Hazardous vapor safety screening:

- Does the vapor headspace exceed 25 percent of the LFL? If so, what are the principal fuel components?

- Are compounds of technological significance present in the tank at such a level that the industrial hygiene group shall be alerted to their presence so adequate breathing zone monitoring can be accomplished and future activities in and around the tank can be performed in a safe manner?

Organic Solvents:

- Does an organic solvent pool exist that may cause an organic solvent pool fire or ignition of organic solvents entrained in waste solids?

The TCP (Winkelman 1996) provides the types of sampling and analysis used to address these issues. Data from the recent analysis of push core samples and tank vapor space measurements, along with available historical information, provided the means to respond to the first two issues. Sections 2.1 and 2.2 present the response. Data from the June 1996 vapor sample provided the means to address the vapor screening issue. See Appendix B for sample and analysis data for tank 241-S-109.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-S-109 for potential safety problems are documented in *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The potential safety problems are exothermic conditions, flammable gases, and criticality conditions in the waste and flammable gases in the tank headspace. These conditions are addressed individually in Sections 2.1.1 through 2.1.3. Because tank 241-S-109 is not a Watch List tank, the safety screening DQO was the only safety-related DQO associated with the sampling effort.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure that tank 241-S-109 does not contain enough exothermic constituents (organic or ferrocyanide) to cause a safety hazard. Because of this requirement, energetics in the tank 241-S-109 waste were evaluated. The safety screening DQO required that the waste sample profile be tested for energetics every 24 cm (9.5 in.) to determine if the energetics exceed the safety threshold limit. This requirement was not met because only a partial core was recovered. The threshold limit for energetics is 480 J/g on a dry weight basis. Results of analysis by differential scanning calorimetry indicated that no sample obtained from tank 241-S-109 had mean exothermic reactions on a dry-weight basis exceeding the safety screening DQO limit. The maximum dry weight exotherm observed was 43.0 J/g with the upper limit to a 95 percent confidence interval of 98 J/g from core 158, segment 2A.

Historical documentation indicates that no exothermic agent should be present in this tank. Waste transfer records indicate that the major waste type expected to be in the tank is evaporator bottoms from the 242-S Evaporator (SMMS1), with a thin layer of REDOX waste in the bottom of the tank (Agnew et al. 1996b).

2.1.2 Flammable Gas

Vapor phase measurements, taken on May 16, 1996 in the tank headspace from riser 11, indicated that no flammable gas was detected (0 percent of the lower flammability limit). Data from the May 16, 1996 vapor phase measurements and June 4, 1996 vapor samples are presented in Appendix B.

2.1.3 Criticality

The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and assuming a density of 1.55 g/mL, 1 g/L of ^{239}Pu is equivalent to 40 μCi/g of alpha activity. All total alpha activity results were well below the safety screening limit. The maximum total alpha activity result was 0.022 μCi/g (core 158, segment 1 lower half) with an upper limit to a 95 percent confidence interval of 0.028 μCi/g, indicating that the potential for a criticality event is extremely low. The method used to calculate confidence limits is described in Appendix C.

2.2 HAZARDOUS VAPOR SAFETY SCREENING

The data required to support vapor screening are documented in *Data Quality Objective for Tank Hazardous Vapor Safety Screening* (Osborne and Buckley 1995). The vapor screening DQO addresses the following two technical issues: 1) Does the vapor headspace exceed 25 percent of the LFL? If so, what are the principal fuel components? 2) Are compounds of technological significance present in the tank at such a level that the industrial hygiene group shall be alerted to their presence so adequate breathing zone monitoring can be accomplished and future activities in and around the tank can be performed in a safe manner?

2.2.1 Flammable Gas

This is the same requirement as the safety screening flammability requirement. See Section 2.1.2 for a treatment of the flammability issue.

2.2.2 Toxicity

The vapor screening DQO requires the analysis of ammonia, carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), nitrous oxide (N_2O), and nitrogen dioxide (NO_2) from a sample. The vapor screening DQO specifies a threshold limit for each of the above listed compounds. Data from the June 1996 vapor sampling event (Huckaby and Bratzel 1995), presented in Appendix B, will be used to address the issue of toxicity. The only analyte to exceed the threshold limits of the vapor safety screening DQO was ammonia. Ammonia had a concentration of 449 ppm (volume basis), over the DQO threshold limit of 25 ppm (volume basis).

2.3 ORGANIC SOLVENTS

The data required to support the organic solvent screening issue are documented in the 93-5 implementation plan (DOE-RL 1996). A new DQO is currently being developed to address the organic solvent issue. In the interim, tanks are to be sampled for total non-methane hydrocarbon, to determine if an organic extractant pool greater than 1 m^2 (10.8 ft^2) exists (Cash 1996). The purpose of this assessment is to ensure that an organic solvent pool fire or ignition of organic solvents cannot occur. Vapor samples taken in June 1996 showed that the concentration of total non-methane organic hydrocarbon in tank 241-S-109 was 3.7 mg/m^3 (Pool et al. 1996). The size of the organic extractant pool will be determined by the organics program, based on the vapor data, tank headspace temperature, and tank ventilation rate.

2.4 HISTORICAL EVALUATION

The historical evaluation was conducted to determine whether the model based on process knowledge and historical information (Brevick et al. 1994, Agnew et al. 1996a) predicts tank inventories that are in agreement with current tank inventories. If the historical model can be shown to accurately predict the waste characteristics as observed through sample characterization, the amount of total sampling and analysis needed may be reduced. Data requirements for this evaluation are documented in *Historical Model Evaluation Data Requirements* (Simpson and McCain 1996).

A "gateway" analysis is a quick check to ensure that the data obtained from sampling support the remainder of the historical evaluation analysis. Failure of the gateway analysis indicates that the model waste composition estimate does not match the sample data and that the tank is not a good candidate for the historical DQO. If the tank fails the gateway analysis, the remainder of the sampling and analysis for the historical DQO will not be applied. If the tank passes, further analyses will be performed on the waste samples as specified in the historical model evaluation DQO. Results of the historical model evaluation DQO will be used to quantify the errors associated with the historical tank content estimates (HTCE).

The gateway analysis was applied to each push core sample taken from tank 241-S-109 in June and July of 1996. The gateway analytes for tank 241-S-109 are sodium, aluminum, chromium, percent water, nitrate, carbonate, and sulfate. These analytes were chosen because the tank waste is predicted to consist entirely of saltcake waste generated from the 242-S Evaporator between 1973 and 1976 (SMMS1).

The gateway analysis required that two tests be performed for each sample. The first was to determine if the gateway analytes contributed to more than 85 percent (by mass) of the total waste. The second was to determine if the concentration of each gateway analyte was over 10 percent of the predicted concentration (as specified in the DQO) for S1 Saltcake (S1SltCk). The waste type S1SltCk no longer exists because of changes in the waste model structure. Evaporator concentrates from later campaigns are now calculated individually on a tank-specific basis using the supernate mixing model (SMM) subroutine. However an analogous comparison can be drawn between SMMS1 and S1SltCk to satisfy the historical DQO requirements. Segment 2 (lower half) was selected for this analysis. The gateway analysis for tank 241-S-109 is shown in Appendix C. Sodium and nitrate alone accounted for 91 percent of the waste mass. The tank passed the first test.

All the gateway analytes except aluminum had concentrations greater than 10 percent of the DQO values for S1SltCk. This analysis passes if the analytical value is greater than 10 percent of the HDW estimate for the tank. The tank passed for all analytes except aluminum (see Appendix C), so the tank failed the second test.

Because tank 241-S-109 failed the gateway analysis and because incomplete cores were obtained, the remainder of the sample analyses specified in the historical model evaluation DQO was not performed. Two reasons that the gateway analysis failed are likely. First, only a portion of the tank was sampled, and these samples may not adequately represent lower portions of the tank. Second, the model predicts the presence of just one waste type (SMMS1) when the tank also received other waste. Further evaluation will be performed later to determine the specific reason that the gateway analysis failed. See Section D1.4 in Appendix D for conclusions about the tank waste contents.

2.5 OTHER TECHNICAL ISSUES

Other factors in assessing tank safety are the temperature of the waste and its capacity to generate heat by radioactive decay. An estimate of 3.70 kW (12,600 Btu/hr) for the tank heat load was given in Agnew et al. (1996b) and a heat load of 2.35 kW (8,000 Btu/hr) was calculated from measured dome space temperatures (Kummerer 1995). A good heat load estimate based on the 1996 analysis of radionuclides was not possible because of incomplete core recovery. However, the two heat load estimates given are below the limit of 11.7 kW (40,000 Btu/hr) that separates high- and low-heat-load tanks (Smith 1986).

2.6 SUMMARY

The results from all analyses performed to address potential safety issues showed that, for the samples obtained, no primary analyte exceeded safety decision threshold limits. Samples from the lower half of the tank could not be obtained by the push core method. There is, however, no historical indication that any waste type other than SMMS1 or REDOX sludge exists in the tank. Neither of these waste types is expected to have exothermic constituents and, based on historical information, neither should represent a safety hazard. The gateway analysis for the historical evaluation DQO failed; no further analyses from the historical DQO will be applied to this tank. Safety screening, vapor screening and historical evaluation results are summarized in Table 2-1.

Table 2-1. Summary of Safety Screening and Historical Evaluation Results.

Issue	Sub-issue	Result
Safety screening	Energetics	Maximum exotherm (dry weight basis) observed in any sample was 43 J/g
	Flammable gas	Vapor measurement reported 0 percent of lower flammability limit. (Combustible gas meter)
	Criticality	All analyses well below 41 μCi/g total alpha
Hazardous vapor	Flammability	See safety screening - flammable gas
	Toxicity	All analytes were within the toxicity threshold limits, except ammonia
Organic solvent	Solvent pool site	Total non-methane hydrocarbon was 3.7 mg/m^3. Organic solvent pool size to be determined.
Historical (gateway analysis)	Total mass of indicators	Passed - Indicator analytes contribute over 96 percent of waste mass for samples obtained
	Comparison of each indicator	Failed - Aluminum concentrations were less than 10 percent of DQO values

3.0 BEST BASIS INVENTORY ESTIMATE

Information about chemical, radiological and/or physical properties of tank waste is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as with regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank waste. Disposal activities involve designing equipment, processes, and facilities for retrieving waste and processing it into a form that is suitable for long-term storage. Chemical and radiological inventory information are generally derived using three approaches: component inventories are estimated using the results of sample analyses, component inventories are predicted using the HDW model based on process knowledge and historical information, and a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material use, and other operating data. Not surprisingly, the information derived using these different approaches is often inconsistent.

An effort is under way to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, available chemical information for 241-S-109 was evaluated. The information included the following:

- Data from 1996 partial core samples (Fritts 1996).
- An inventory estimate generated by the HDW model (Agnew et al. 1996b).
- An evaluation of the average REDOX high level waste (R) flowsheet.

The best basis inventory evaluation is included in Appendix D. Based on this evaluation, a best basis inventory was developed (Tables 3-1 and 3-2). In general, the sample-based results were preferred when they were reasonable and consistent with other results. Process estimates were added to the sample-based results for the analytes that appear on the R flowsheet. This was done to add the estimated contribution from the sludge layer, which was a minor component of this tank. Because no sample was available for this layer, the engineering assessment must be considered to have a low confidence value. The HDW model was used only where no other data were available.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-109 (11/9/96).

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1,2]	Comment
Al	21,100	E	This value may be as much as 4 times low
Bi	288	M	
Ca	245	E	
Cl	937	E	
TIC as CO_3	12,000	E	
Cr	5370	E	
F	1450	M	
Fe	3,410	E	
Hg	42.6	M	
K	3,350	M	
La	4.0E-03	M	
Mn	54.4	E	
Na	6.25E+05	E	
Ni	667	M	
NO_2	11,360	E	This value may be as much as 10 times too low, based on similar tanks.
NO_3	1.47E+06	E	
OH	2.56E+05	M	
Pb	1,480	M	
P as PO_4	30,900	E	
Si	977	E	
S as SO_4	19,950	E	
Sr	8.41E-04	M	
TOC	1,510	E	
U_{TOTAL}	142	E	
Zr	87.2	M	

Notes:

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based

[2]Sample data were not used because sample recovery was poor and samples were obtained from only the upper portion of the tank (see Appendix B).

Table 3-2. Best Basis Inventory Estimates for Radioactive Components in Tank 241-S-109 (11/9/96).

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1, 2]	Comment
^{90}Sr	2.76 E+05	E	Based on calculations from dome space temperatures
^{137}Cs	1.06+05	E	Based on calculations from dome space temperatures

Notes:

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based
NR = Not reported.

[2]Sample data were not used because sample recovery was poor and samples were obtained from only the upper portion of the tank (see Appendix B).

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4.0 RECOMMENDATIONS

All analytical results for the safety screening DQO were well within the safety notification limits. However, the full depth of the waste was not sampled during the June/July 1996 push core sampling event. Therefore, the tank cannot be classified as "safe." The June 4, 1996 vapor sample provided sufficient information to address the needs of the hazardous vapor safety screening DQO (Osborne and Buckley 1995) and the organic solvent screening issue (Cash 1996). No further vapor sampling efforts are necessary. The gateway analysis for the historical DQO failed for the samples obtained. Further evaluation of the available data will be performed at a later time to determine why the gateway analysis failed. The sampling and analysis activities performed for tank 241-S-109 have met only part of the requirements for all of the applicable DQO documents. A characterization best basis inventory was developed for the tank contents based on sample information and historical tank transfer data.

Table 4-1 summarizes the status of the Project Hanford Management Contract (PHMC) TWRS Program office review and acceptance of the sampling and analysis results reported in this tank characterization report. All DQO issues required to be addressed by sampling and analysis are listed in Column 1 of Table 4-1. Column 2 indicates by a "yes" or "no" entry whether the requirements of the DQO were met by the sampling and analysis activities performed." Column 3 indicates by a "yes" or "no" entry whether the TWRS program responsible for the DQO concurs that the sampling and analysis activities performed adequately meet the needs of the DQO. If the results/information have not yet been reviewed, "NR" is shown in the column. If the results/information have been reviewed, but acceptance or disapproval has not been decided, "ND" is shown in the column. Because waste was only sampled in the top portion of the tank (see Section B3.1), the safety screening DQO has been only partially completed. The upper part of the waste was sampled and analyzed in accordance with the safety screening DQO and conditionally accepted by the responsible TWRS program.

Table 4-1. Acceptance of Tank 241-S-109 Sampling and Analysis.

Issue	Sampling and Analysis Performed	PHMC TWRS Program Acceptance
Safety screening DQO	Partial	Partial
Hazardous vapor safety screening DQO	Yes	Yes
Organic solvent	Yes	Yes
Historical evaluation DQO	Partial	Partial

Table 4-2 summarizes the status of the TWRS Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluations specifically included are the best basis inventory evaluation, the gateway analysis, and the evaluation to determine whether the tank is safe, conditionally safe, or unsafe. Column 1 lists the different evaluations performed in this report. Columns 2 and 3 are in the same format as Table 4-1. Concurrence and acceptance are summarized the same way as in Table 4-1. The safety categorization of the tank is listed as "partial" in Table 4-2 because the full depth of the waste was not sampled. However, none of the analyses performed on the push core samples indicate any safety problems.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-S-109.

Issue	Evaluation Performed	PHMC TWRS Program Acceptance
Safety categorization (tank is safe)	Partial	Partial
Hazardous vapor	Yes	Yes
Organic solvent	No	NR
Historical "gateway" analysis	Partial	Yes

Note:
NR = Not reviewed

Tank 241-S-109 may need to be resampled using rotary-mode core sampling to provide the two full-depth profiles required by the safety screening DQO (Dukelow et al. 1995). The information available on tank 241-S-109 should be evaluated further to determine if additional samples are needed to categorize the tank as "safe."

5.0 REFERENCES

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-S-109 based on historical information. For this report, historical information includes any information about the fill history, waste types, surveillance, or modeling data about the tank. This information is needed to provide a balanced assessment of the sampling and analytical results.

This appendix contains the following information:

- **Section A1**. Current status of the tank, including the current waste levels.
- **Section A2**. Information about the design of the tank.
- **Section A3**. Process knowledge of the tank, i.e., the waste transfer history and the estimated contents of the tank based on modeling data.
- **Section A4**. Surveillance data for tank 241-S-109, including surface-level readings, temperatures, and a description of the waste surface based on photographs.
- **Section A5**. References for Appendix A.

Historical sampling results (results from samples obtained before May of 1989) are included in Appendix B.

A1.0 CURRENT TANK STATUS

As of August 1996, Tank 241-S-109 contained an estimated 1,920 kL (507 kgal) of waste classified as noncomplexed (Agnew et al. 1996b). The liquid waste volume is estimated using a surface level gauge. Solid waste volume is estimated using a combination of a photographic evaluation and a sludge level measurement device. The solid waste volume was last updated on June 30, 1996. Table A-1 lists the amounts of various waste phases in the tank.

Tank 241-S-109 is out of service, as are all single-shell tanks, and is categorized as sound. The tank is not on any watch lists (Public Law 101-510, 1990). The tank is passively ventilated and partially interim isolated. All monitoring systems were in compliance with documented standards as of August 31, 1996 (Hanlon 1996).

Table A1-1. Tank Inventory Summary.

Waste Type	kL (kgal)
Total waste	1,920 (507)[1]
Supernatant liquid	0 (0)[2]
Sludge	49 (13)[2]
Saltcake	1,870 (494)[1]
Drainable interstitial liquid	534 (141)[2]
Drainable liquid remaining	534 (141)[2]
Pumpable liquid remaining	450 (119)[2]

Notes:

[1]Agnew et al. (1996b). This volume is lower than Hanlon (1996), which does not include a transfer of 230 kL (61 kgal) from tank 241-S-109 in 1985.

[2]Hanlon (1996)

A2.0 TANK DESIGN AND BACKGROUND

The 241-S Tank Farm was constructed during 1950 and 1951 in the 200 West Area. The farm contains twelve 100 series tanks. The tanks have a capacity of 2870 kL (758 kgal), diameter of 23 m (75 ft), and operating depth of 7 m (23 ft) (Leach and Stahl 1993). Built according to the second generation design, the 241-S Tank Farm was designed for waste with a maximum fluid temperature of 104 °C (220 °F) (Brevick et al. 1996). A cascade overflow line 76 mm (3 in.) in diameter connects 241-S-109 as third in a three-tank cascade series with tanks 241-S-107 and -108. Each tank in the series is set 0.3 m (1 ft) lower in elevation than the preceding tank. The cascade overflow height is approximately 6.9 m (22.7 ft) from the tank bottom and 0.4 m (1.2 ft) below the top of the steel liner (Leach and Stahl 1996).

The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle. Tank 241-S-109 was designed with a primary mild steel liner (ASTM A283 Grade B) and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. The tank and foundation were waterproofed using a coating of tar covered by a three-ply, asphalt-impregnated, waterproofing fabric. The waterproofing was protected by welded-wire-reinforced gunite. One coat of primer was sprayed on all exposed interior tank surfaces. The ceiling of the tank dome was covered with six applications of a vinyl resin coating (Rutherford 1949). Lead flashing was used to protect the joint where the steel liner meets the concrete dome.

Asbestos gaskets were used to seal the risers in the tank dome. This tank was covered with approximately 2 m (6 ft) of overburden (see Figure A2-2).

Tank 241-S-109 has 12 risers according to the drawings and engineering change notices. The risers range in diameter from 100 mm (4 in.) to 1.07 m (42 in.). Table A2-1 shows numbers, diameters, and descriptions of the risers and the inlet, overflow, and spare nozzles. Figure A-2 is a plan view depicting the riser configuration. Risers 2, 11, 14, and 16 and riser 6 are available for sampling (Lipnicki 1996). Figure A-2 is a tank cross section showing the approximate waste level along with a schematic of the tank equipment.

A3.0 PROCESS KNOWLEDGE

Sections A3.1 and A3.2 provide information about the transfer history of tank 241-S-109, describe the process waste that was transferred, and give an estimate of the current tank contents based on the transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-S-109 (Agnew et al. 1996a). The first transfer to Tank 241-S-109 was high-level REDOX (S Plant) waste transferred in the fourth quarter of 1952 via the cascade from tank 241-S-108. REDOX high-level waste was transferred into tank 241-S-109 until the second quarter of 1953. From the fourth quarter of 1954 through the second quarter of 1955, REDOX cladding waste cascaded to tank 241-S-109 from tank 241-S-108. The waste in tank 241-S-109 then remained static until the fourth quarter of 1973. From the first to the fourth quarters of 1974, 242-S Evaporator feed waste was sent to tank 241-S-109, and 242-S Evaporator bottoms waste was received from tank 241-S-102. Supernatant waste was sent to tank 241-SY-102 from the third quarter of 1978 until the second quarter of 1979. In the third quarter of 1985, 241-S-109 was saltwell pumped with the resulting liquid sent to tank 241-AW-102.

Table A2-1. Tank 241-S-109 Risers.
(Alstad 1993, Tran 1993, Vitro 1988)

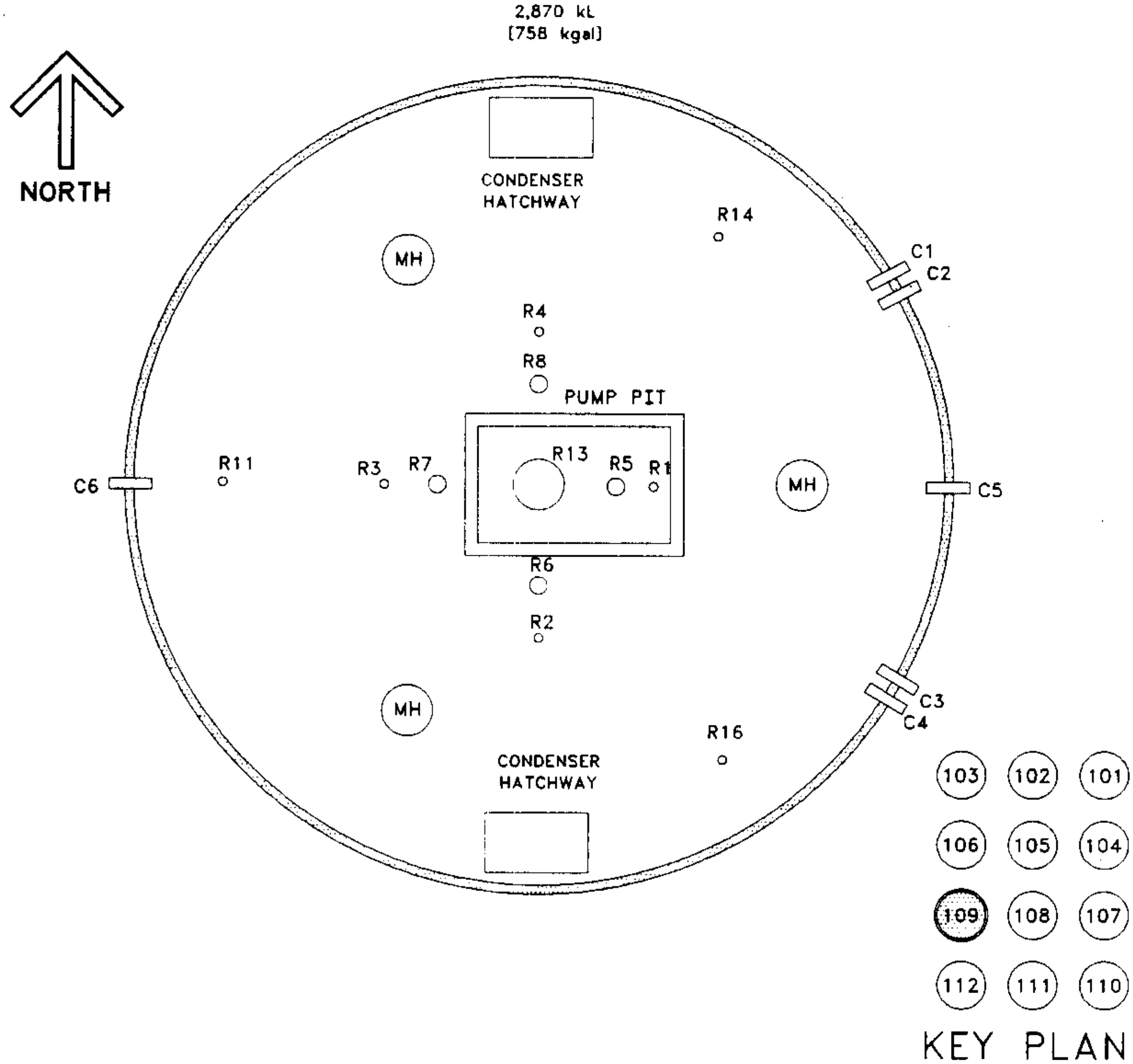
Number	Diameter (Inches)	Description and Comments
R1	4	Connector nozzle
R2	4	Blind flange (benchmark, CEO-36907, 12/11/86) (breather filter, CEO-41064, 3/17/87) (4" x 4" x 4" offset adapter w/breather filter, ECN-626615, 11/16/95)
R3	4	ENRAF[1] gauge, ECN-622487, 4/21/95 (formerly Food Instrument Corporation [FIC] gauge)
R4	4	Thermocouple tree
R5	12	Saltwell screen and pump
R6	12	Spare (B-222 observation port, CEO-41064, 3/17/87)
R7	12	Ventilation (blank, CEO-41064, 3/17/87) (duct removed & riser capped, ECN-706501, 8/29/95)
R8	12	B-436 liquid observation well (LOW)
R11	4	Sludge measurement port
R13	42	Slurry distributor
R14	4	Sludge measurement port
R16	4	Sludge measurement port [benchmark, CEO-36907, 12/11/86)
C1	3	Spare nozzle, capped
C2	3	Spare nozzle, capped
C3	3	Spare nozzle, capped
C4	3	Spare nozzle, capped
C5	3	Inlet
C6	3	Outlet, capped

Notes:

CEO = Change engineering order
ECN = Engineering change notice

[1]ENRAF is a trademark of the ENRAF Corporation, Houston, Texas.

Figure A2-1. Riser Configuration for Tank 241-S-109.



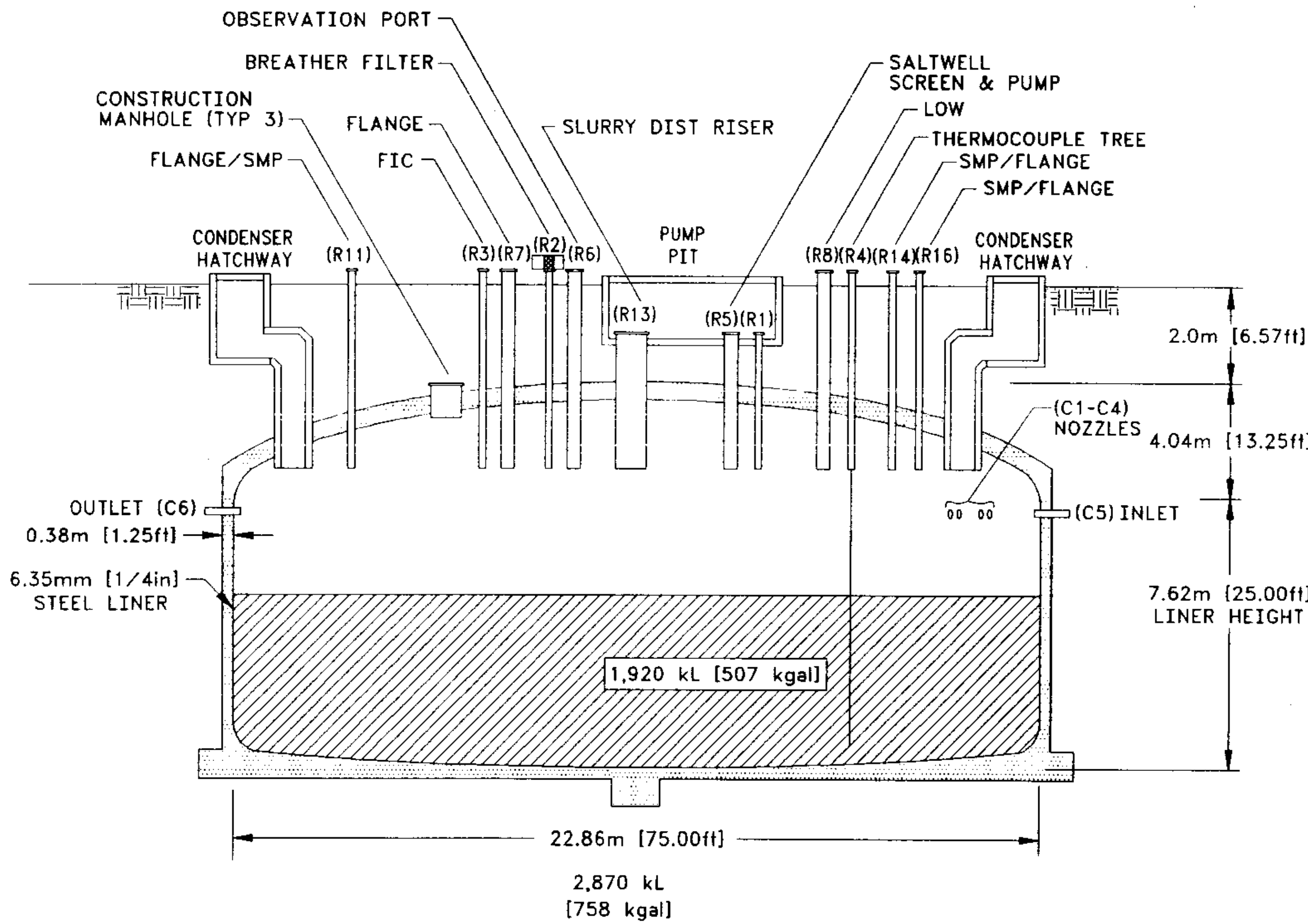


Figure A2-2. Tank 241-S-109 Cross Section and Schematic.

Table A3-1. Tank 241-S-109 Major Transfers. (Agnew et al. 1996b)

Transfer Source	Transfer Destination	Waste Type Received	Time Period	Estimated Waste Volume[1]	
				kL	kgal
241-S-108		R	1952 - 1953	2 271	600
241-S-108		CWR	1954 - 1955	768	203
241-S-102		EB	1974	10 670	2 819
	S-102	R, EB	1974	-8 282	-2 188
	SY-102	PNF	1978 - 1979	-625	-165
	AW-102	swliq	1985	-230	-61

Notes:

R REDOX high-level waste (HLW) was generated from 1952 to 1966. It used methylisobutylketone (hexone) as a solvent, and extracted both uranium and plutonium (S Plant). Ran from January 1952 to December 1967.

CWR Cladding waste (REDOX)

EB Evaporator bottoms

PNF Partial neutralization feed. Indicates addition of nitric acid at an evaporator in an attempt to produce more saltcake during volume reduction.

swliq Dilute, noncomplexed waste from single-shell tanks

[1]Because only major transfers are listed, the sum of these transfers will not equal the current tank waste volume.

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 East Area* (WSTRS) (Agnew et al. 1996a) WSTRS is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev 3* (Agnew et al. 1996b). This document contains the Hanford Defined Waste [HDW] list, the Supernatant Mixing Model [SMM], and the Tank Layer Model [TLM]).

- *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area* (HTCE) (Brevick et al. 1996).

Using these records, the TLM defines the sludge and saltcake layers in each tank. The SMM uses information from both the WSTRS and the TLM to describe the supernates and concentrates in each tank. Together the WSTRS, TLM, and SMM determine each tank's inventory estimate. These model predictions are considered estimates that require further evaluation using analytical data.

Based on the TLM and SMM, Tank 241-S-109 contains 1920 kL (507 kgal) of solids waste made up of a bottom layer of 49 kL (13 kgal) of REDOX cladding waste (CWR1) beneath a top solids layer of 1870 kL (494 kgal) of concentrated supernatant solids (SMMS1) waste. The supernatant solids were derived from salt slurry generated in the 242-S Evaporator. Figure A3-1 is a graphical representation of the estimated waste types and volumes for each tank layer.

The CWR1 layer should contain above 1 weight percent of hydroxide, aluminum, sodium, nitrite, uranium, nitrate, and lead. Constituents contained in this layer above 0.1 weight percent are iron, carbonate, and calcium. Process data indicate that the sludge layer is likely REDOX high-level (R) waste rather than CWR1 as predicted by Agnew et al. (1996b). The main difference between R and CWR1 waste is that R waste is expected to have much greater radioactivity because large amounts of ^{90}Sr and ^{137}Cs are present. R waste also is expected to have over 10 times greater concentrations of ammonia, chromium, and nickel and more than 10 times lower concentrations of nitrate than CWR1 waste.

The SMMS1 layer is predicted to consist of greater than 1 weight percent sodium, aluminum, hydroxide, nitrate, carbonate, and sulfate, and between 1 and 0.1 weight percent chromium, potassium, phosphate, silicon, total organic carbon, and uranium (Agnew et al. 1996b).

Table A3-2 shows an estimate of the expected waste constituents and concentrations.

A4.0 SURVEILLANCE DATA

Tank 241-S-109 surveillance includes surface level measurements (liquid and solid) and temperature monitoring inside the tank (waste and vapor space). The data provide the basis for determining tank integrity.

Liquid level measurements may indicate if there is a major leak from a tank. Solid surface level measurements provide an indication of physical changes and consistency of the solid layers. Tank 241-S-109 has six drywells; none is active.

Figure A3-1. Tank Layer Model for Tank 241-S-109.

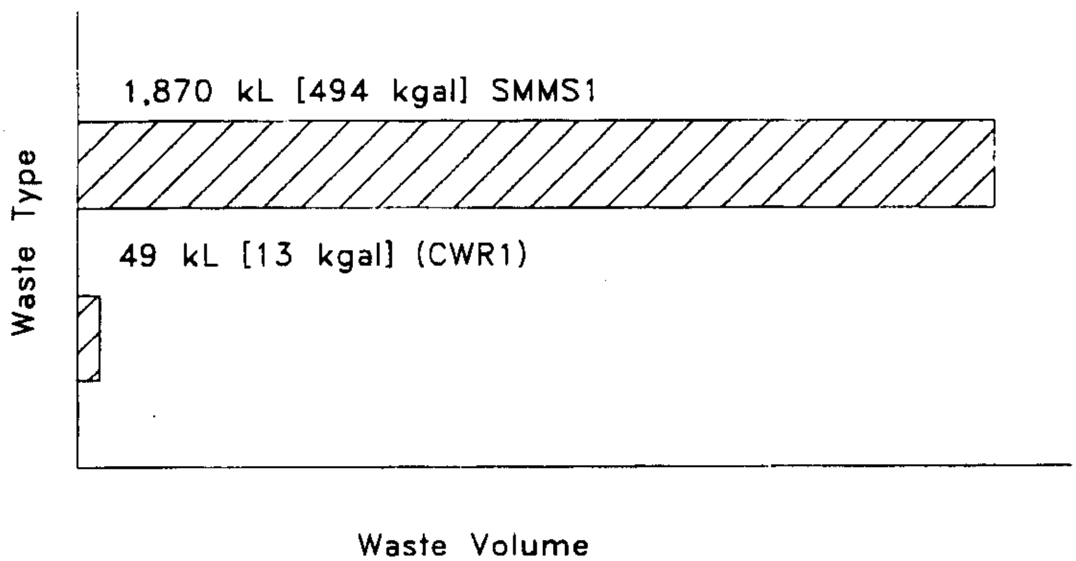


Table A3-2. Historical Tank Inventory Estimate. (2 sheets)

Total Inventory Estimate[1,2]			
Physical Properties			
Total solid waste	2.92E+06 kg (507 kgal)		
Heat load	3.70 kW (1.26E+04 Btu/hr)		
Bulk density	1.52 (g/cc)		
Water wt%	40.1		
Total organic carbon wt% carbon (wet)	0.358		
Chemical Constituents	**Mole/L**	**ppm**	**kg[3]**
Na^{+}	10.6	1.60E+05	4.67E+05
Al^{3+}	1.87	3.33E+04	9.70E+04
Fe^{3+} (total Fe)	1.09E-02	401	1.17E+03
Cr^{3+}	6.82E-02	2.34E+03	6.81E+03
Bi^{3+}	7.18E-04	98.7	288
La^{3+}	1.50E-08	1.37E-03	4.00E-03
Hg^{2+}	1.11E-04	14.6	42.6
Zr (as $ZrO(OH)_2$)	4.98E-04	29.9	87.2
Pb^{2+}	3.72E-03	507	1.48E+03
Ni^{2+}	5.92E-03	229	667
Sr^{2+}	5.00E-09	2.89E-04	8.41E-04
Mn^{4+}	3.01E-03	109	318
Ca^{2+}	3.34E-02	882	2.57E+03
K^{1+}	4.46E-02	1.15E+03	3.35E+03
OH^{-}	7.84	8.77E+04	2.56E+05
NO_3^{-}	4.67	1.90E+05	5.55E+05
NO_2^{-}	2.60	7.86E+04	2.29E+05
CO_3^{2-}	0.283	1.12E+04	3.26E+04
PO_4^{3-}	6.21E-02	3.89E+03	1.13E+04

Table A3-2. Historical Tank Inventory Estimate. (2 sheets)

Chemical Constituents	Mole/L	ppm	kg[3]
SO_4^{2-}	0.179	1.13E+04	3.30E+04
Si (as SiO_3^{2-})	6.87E-02	1.27E+03	3.70E+03
F^-	3.98E-02	497	1.45E+03
Cl^-	0.174	4.07E+03	1.19E+04
$C_6H_5O_7^{3-}$	2.28E-02	2.84E+03	8.27E+03
$EDTA^{4-}$	2.26E-03	429	1.25E+03
$HEDTA^{3-}$	3.70E-03	668	1.95E+03
glycolate$^-$	3.74E-02	1.85E+03	5.39E+03
acetate$^-$	2.63E-03	102	298
oxalate^{2-}	1.28E-08	7.44E-04	2.17E-03
DBP	1.48E-02	2.59E+03	7.54E+03
Butanol	1.48E-02	721	2.10E+03
NH_3	5.50E-02	616	1.80E+03
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu		8.73E-02 (μCi/g)	4.24 (kg)
U	1.63E-02 (M)	2.55E+03 (μg/g)	7.44E+03 (kg)
Cs	0.251 (Ci/L)	165 (μCi/g)	4.82E+05 (Ci)
Sr	0.111 (Ci/L)	73.4 (μCi/g)	2.14E+05 (Ci)

Notes:

[1]Agnew et al. (1996b)

[2]These predictions have not been validated and should be used with caution.

[3]Differences exist among the inventories in this column and the inventories calculated from the two sets of concentrations.

A4.1 SURFACE LEVEL READINGS

A Food Instrument Corporation (FIC) gauge was used to monitor the surface level of the waste through riser 3 in the automatic mode until June 14, 1990 and in the manual mode until July 1, 1995. Then the FIC gauge was replaced with an ENRAF™ surface level system. On September 16, 1996 the waste surface level was 4.37 m (172.05 in.). Figure A4-1 presents the volume measurements as a level history graph. Three lines are shown on this figure. The solid line represents the total tank waste level, the dashed line represents the solids level, and the third line (between 1979 and 1996) is the interstitial liquid level.

The equivalent tank volume for the most recent surface level reading is 1720 kL (453 kgal). This is lower than the tank volume estimate based on transfer data (Agnew et al. 1996a) and is attributed to the plummet for the measuring device entering a deep depression in the crust at the center of the tank. The Agnew et al. (1996a) volume was computed by adding 45.7 cm (18 in) to the measured surface level depth to correct for surface irregularities. However, the actual depth of the collapsed central area is unknown (Swaney 1993).

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-S-109 has a single thermocouple tree, located in riser 4, with 12 thermocouples to monitor the waste temperature. Temperature data, recorded from January 4, 1991, through September 16, 1996, were obtained from the Westinghouse Hanford Company Surveillance Analysis Computer System (SACS) for 11 thermocouples; no data were available for thermocouple 11. The average temperature of the SACS data is 26.1°C (79°F), the minimum is 12.9°C (55.3°F), and the maximum is 31.9°C (89.4°F). The average temperature of the SACS data from September 1995 through September 1996 is 26.2°C (79.1°F), the minimum is 16.4°C (61.5°F), and the maximum is 31.9°C (89.4°F). The high temperature on September 16, 1996 was 29.6°C (85.3°F) on thermocouple 3 (located in the waste) and the low was 23.9°C (75°F) on thermocouple 12 (located in the vapor space). A graph of the weekly high temperatures can be found in Figure A2-2. Plots of the individual thermocouple readings can be found in the S Tank Farm Supporting Document for the HTCE (Brevick et al. 1995).

A4.3 TANK 241-S-109 PHOTOGRAPHS

The August 1984 photographic montage of the tank 241-S-109 interior shows the surface of the waste to be dry and off-white. The surface is similar to that in other tanks containing saltcake. A level-measuring device, a thermocouple tree, and a saltwell are visible in the background. Some debris can also be seen on the waste surface. The waste level in the tank has not changed since before the photographs were taken; therefore, the montage should resemble the current appearance of the tank's interior.

Figure A4-1. Tank Level History for Tank 241-S-109.

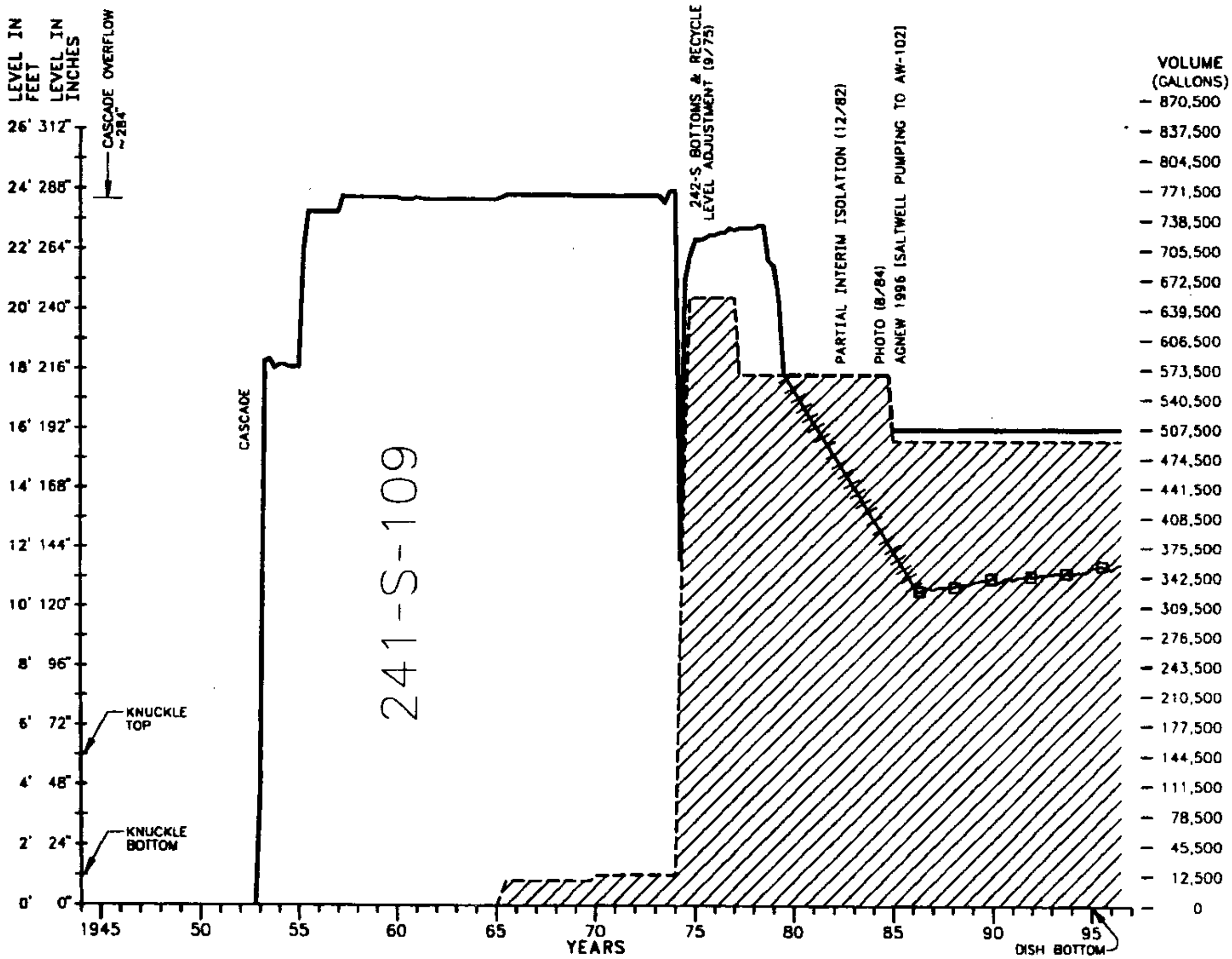
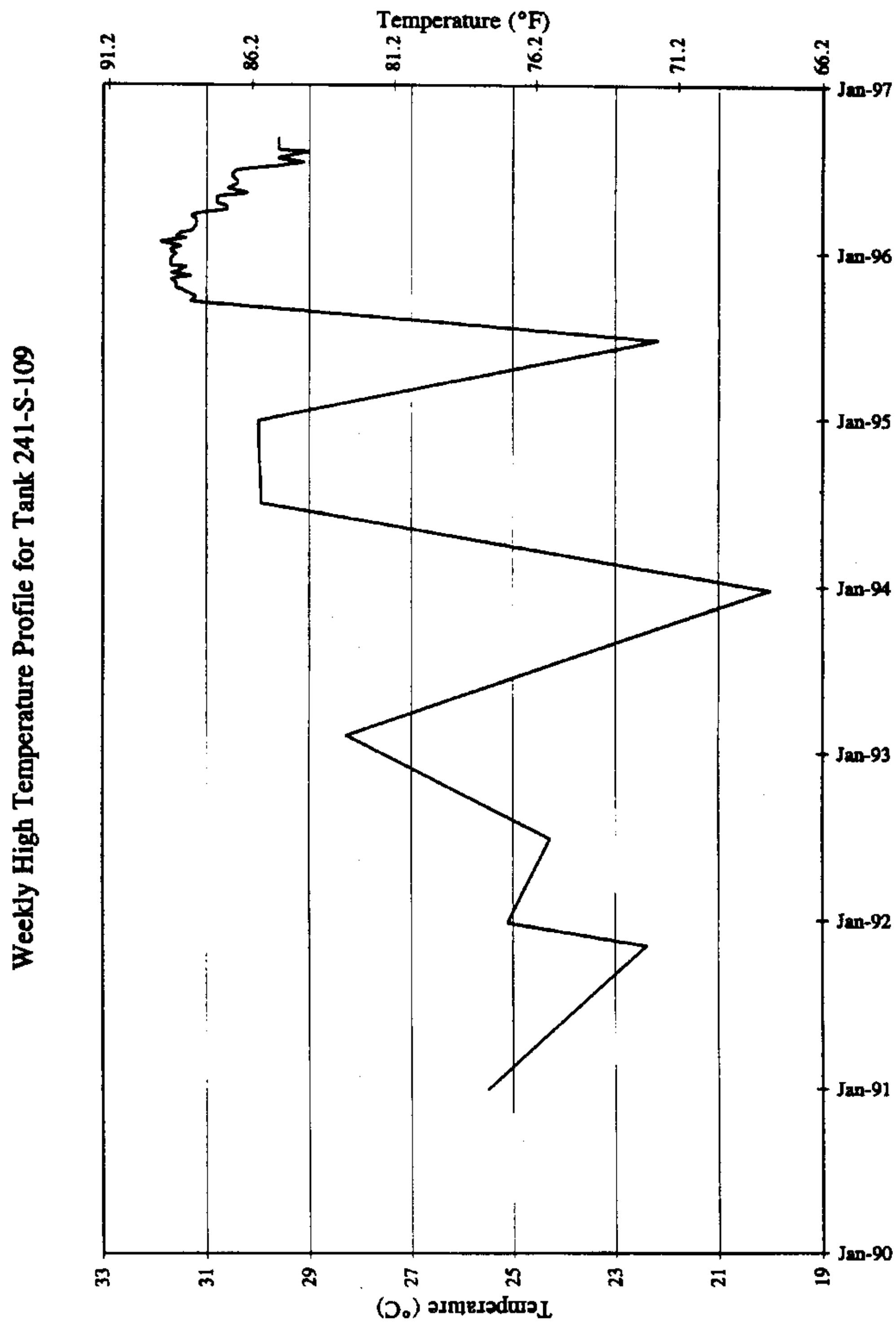


Figure A4-2. Weekly High Temperature Plot for Tank 241-S-109.



A5.0 APPENDIX A REFERENCES

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APPENDIX B

SAMPLING OF TANK 241-S-109

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APPENDIX B

SAMPLING OF TANK 241-S-109

Appendix B provides sampling and analysis information for each known sampling event for tank 241-S-109 and also provides an assessment of the analysis results.

- **Section B1**: Tank Sampling Overview

- **Section B2**: Analytical Results
  - **B2.1** 1996 Push Core Sampling Event
  - **B2.2** 1996 Vapor Sample
  - **B2.3** Historical Sampling Event.

- **Section B3**: Assessment of Characterization Results

- **Section B4**: References for Appendix B.

Future sampling of tank 241-S-109 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

This section describes the sampling and analysis events for tank 241-S-109. Push core samples were taken during June and July to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), and the *Historical Model Evaluation Data Requirements* (Simpson and McCain 1996). The sampling and analyses were performed in accordance with the *Tank 241-S-109 Push Core Sampling and Analysis Plan* (Field 1996). A vapor sample was taken from this tank in April 1996 to satisfy the *Data Quality Objectives for Tank Hazardous Vapor Screening* (Osborne and Buckley 1995) and the organic solvent screening issue (DOE-RL 1996 and Cash 1996). Sampling and analysis were performed in accordance with the vapor sampling and analysis plan (Homi 1996).

Sampling and analytical requirements from the safety screening and the historical and vapor screening DQOs are summarized in Table B1-1.

Table B1-1. Integrated Requirements for Tank 241-S-109. (Homi 1996)

Sampling Event	Applicable DQOs	Sampling Requirements	Applicable References
Push/rotary -mode core sampling	SAFETY SCREENING - Energetics - Moisture Content - Total Alpha - Flammable Gas HISTORICAL	Core samples from a minimum of two risers separated radially to the maximum extent possible.	Dukelow (1995) Simpson and McCain (1996)
Vapor sampling	HAZARDOUS VAPOR - Flammable Gas - Toxicity ORGANIC SOLVENT	Steel canisters, Triple sorbent traps, sorbent trap systems	Osborne and Buckley (1995) DOE-RL (1996) Cash (1996)

B2.0 1996 PUSH CORE SAMPLING EVENT

Two cores of 12 segments were expected from tank 241-S-109 during the June/July 1996 sampling event. However, sampling problems resulted in only partial cores being obtained.

The top 4 segments (119 cm [47 in.]) of core 158 were obtained from riser 14 between June 21 and June 27, 1996. Segments 1 and 2 were pushed until a maximum downforce was reached. Water was added to soften the waste before pushing segment 2A. Segment 2A was retrieved after a stroke of 22 cm (8.75 in.). Segment 2B was then attempted, but was terminated because a maximum down force pressure was reached after penetrating only 13 cm (5 in.). Lithium bromide traced water was added to soften the waste before pushing segments 3 and 3A. Segment 4 was retrieved after breaking through a hard layer and penetrating 10 cm (4 in.). Riser 14 was abandoned when another hard layer was hit and the sampler could not penetrate further.

Core 160 (riser 16) was sampled on July 2, 1996. Segment one was retrieved with 58 percent recovery. Only 20 cm (7.75 in.) of segment 2 could be pushed before a maximum downforce was reached. Segments 2A, 2B, and 2C were attempted on July 2, 1996. Lithium-bromide-traced water was again added to soften the waste before the core was abandoned because maximum downforce was reached repeatedly with little penetration. In addition to segment samples, a field blank obtained on July 8, 1996, and a lithium bromide blank, were sent to the 222-S Laboratory for analysis.

B2.1 SAMPLE HANDLING

Two partial cores were received by the Westinghouse Hanford Company 222-S Laboratory between July 9 and July 16, 1996. The samples were extruded between July 16 and July 22, 1996. Each sample was homogenized and analyzed separately by the 222-S Laboratory. Repeat samples were analyzed separately and designated by the letters A, B, or C. Liner liquid was collected for segments 2 and 3 of core 158 and segments 2A and 2B of core 160. Drainable liquid was observed in core 160, segment 2C only. This was mostly lithium bromide tracer fluid (see Section 3.2).

Table B2-1 describes core 158 and 160, including segment numbers, phase (solid or liquid), color, texture, and amount of material recovered.

B2.2 SAMPLE ANALYSIS

Samples and subsamples from core 158 and core 160 were analyzed based on safety screening and historical DQOs. Analyses included: total alpha activity, energetics, water content, flammable gas, total organic carbon, total inorganic carbon, bulk density, IC, ICP, and GEA.

Samples were separated for analysis at the half-segment level where both liner liquid and solids were present, and for core 158, segment 2B where a difference in color was observed between the upper and lower portions of the solids.

Weight percent water was determined by thermogravimetric analysis (TGA). The fuel content of the waste was determined by differential scanning calorimetry (DSC). Metals were measured using inductively coupled plasma/atomic emission spectroscopy (ICP); before analysis the subsamples were prepared by both a fusion and an acid digest. Anions were measured on water-leached samples using ion chromatography (IC). Total organic carbon was measured using hot persulfate oxidation and coulometry. Total alpha activity, gamma energy analysis was performed on fusion-digested samples. Density was measured using centrifugation. Table B2-2 provides further information regarding the various laboratory procedures used to analyze these samples.

Only a small amount of solids were retrieved for core 160, segment 2A. As a result, bulk density analyses were not conducted on this sample, the sample was not homogenized or archived, and only water-digest IC/ICP analyses were performed.

Liner liquids were analyzed for metals and anions using ICP and IC. No other analyses were conducted.

The segments, segment portions, individual sample numbers, and the analyses performed on each sample are summarized in Table B2-3.

Table B2-1. Sample Description. (Fritts 1996) (2 sheets)

Segment	Sample ID	Sample Weight (g)		Segment Description
		Solid	Liquid	
Core 158, Riser 14				
1	96-362	177.8	0	Extruded 20 cm of solids and no liquid. Upper half solids (6.5 cm) were gray and resembled a moist crumbly saltcake. Lower half solids (12.5 cm) were yellow and resembled moist crumbly saltcake.
2	96-363	38.9	60.8	Extruded 6.5 cm of solids and 60 mL of liner liquid. Solids were yellow and resembled dry crumbly saltcake. Liner liquid was dark gray and opaque.
2A	96-363A	23.9	0	Extruded 5 cm of solids and no liquid. Solids were light yellow with small gray pieces and resembled dry saltcake.
2B	96-363B	64.5	0	Extruded 13 cm of solids and no liquid. Upper half solids were blue-gray and resembled moist saltcake. Lower half solids were light yellow and resembled moist saltcake.
3	96-364	128.6	116.2	Extruded 13 cm of solids and 125 mL of liner liquid. Upper half solids were gray-white and resembled dry saltcake. Lower half solids were yellow and resembled dry saltcake. The liner liquid was light gray and opaque.
3A	96-364A	107.2	0	Extruded 13 cm of solids and no liquid. Solids were yellow with a light gray tint on the upper end and resembled dry crumbly saltcake.
4	96-365	80.9	0	Extruded 13 cm of solids and no liquid. Solids were light gray-white and resembled a flaky, moist saltcake.

Table B2-1. Sample Description. (Fritts 1996) (2 sheets)

Segment	Sample ID	Sample Weight (g)		Segment Description
		Solid	Liquid	
Core 160, Riser 16				
1	96-378	61.7	0	Extruded 15 cm of solids and no liquid. Solids were gray-white and resembled dry saltcake.
2	96-379	77.0	0	Extruded 15 cm of solids and no liquid. Solids were light yellow with a small amount of light green-gray crystals and resembled dry saltcake.
2A	96-379A	6.0	15.0	Extruded 2.5 cm of solids and 15 mL of liner liquid. Solids were light yellow with a slight green tint and resembled fine, crumbly, dry saltcake. The liner liquid was dark gray and opaque.
2B	96-379B	62.5	125.2	Extruded 9 cm of solids and 125 mL of liner liquid. Upper half solids were yellow with a gray tint. Lower half solids were gray. All solids resembled dry, crumbly saltcake. Liner liquid was slightly yellow and opaque.
2C	96-379C	n/a	68.8	Extruded an unmeasurable amount of solids and 50 mL of drainable liquid. Separation of liquids and solids was not possible. The solids were gray and resembled wet salt. Drainable liquid was green and opaque. All of the sample was subsampled as drainable liquid. The filtered solids were archived.

Table B2-2. Analytical Procedures. (Field 1996)

Analysis	Method	Procedure Number
Energetics by DSC	Mettler[1] Perkin-Elmer[2]	LA-514-113, Rev. C-1 LA-514-114, Rev. C-1
Percent water by TGA	Mettler[1] Perkin-Elmer[2]	LA-560-112, Rev. B-1 LA-514-114, Rev. C-1
Bulk density	Gravimetry	LO-160-103, Rev. B-0
Total alpha activity	Alpha proportional counter	LA-508-101, Rev. D-2
Flammable gas	Combustible gas analyzer	WHC-IP-0030 IH 1.4 and IH-2.1[3]
Total Organic Carbon/ Total Inorganic Carbon	Coulometer	LA-342-100, Rev. E-0
Metals by ICP	Inductively coupled plasma spectrometer	LA-505-151, Rev. D-3 LA-505-161, Rev. B-1
Radionuclides	GEA	LA-548-121, Rev. E-0
Anions by IC	Ion chromatograph	LA-533-105, Rev. D-1
Uranium	Kinetic Phosphorescence	LA-925-009, Rev. A-1
Total beta	Beta proportional counting	LA-508-101, Rev. D-2
Strontium	Extraction/beta proportional counting	LA-220-101, Rev. D-1

Notes:

n/a = not applicable

[1]Mettler is registered trademark of Mettler Electronics, Anaheim, California.

[2]Perkin-Elmer is a registered trademark of Perkins Research and Manufacturing Company, Inc., Canoga Park, California.

[3]Safety Department Administrative Manuals, Westinghouse Hanford Company, Richland, Washington:
IH 1.4, Industrial Hygiene Direct Reading Instrument Survey
IH 2.1, Standard Operating Procedure, MSA Model 260 Combustible Gas and Oxygen Analyzer.

Table B2-3. Summary of Samples and Analyses. (Fritts 1996a) (4 sheets)

Segment	Segment Portion	Waste Matrix	Sample Number	Analyses
Core 158				
Field Blank	Drainable Liquid	Liquid	S96T004023 S96T004024	Alpha, IC, ICP, DSC, TGA, SpG Archive
1	Upper ½	Saltcake	S96T003916 S96T003922 S96T003935 S96T003941 S96T003947 S96T003928	Density DSC, TGA, TIC/TOC Alpha(fusion), GEA ICP (acid digest) IC (water digest) Archive
	Lower ½	Saltcake	S96T003917 S96T003923 S96T003936 S96T003942 S96T003948 S96T003929	Density DSC, TGA, TIC/TOC Alpha(fusion), GEA ICP (acid digest) IC (water digest) Archive
2	Liner Liquid	Liquid	S96T003755 S96T003756	IC, ICP Archive
	Lower ½	Saltcake	S96T003733 S96T003734 S96T003737 S96T003752 S96T003753 S96T003778	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, Beta, GEA, ^{90}Sr, U ICP (acid digest) IC (water digest) ICP (water digest)
2A	Lower ½	Saltcake	S96T004016 S96T004017 S96T004018 S96T004019 S96T004020	Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)

Table B2-3. Summary of Samples and Analyses. (Fritts 1996a) (4 sheets)

Segment	Segment Portion	Waste Matrix	Sample Number	Analyses
2B	Upper ½	Saltcake	S96T003757 S96T003759 S96T003763 S96T003765 S96T003767	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)
	Lower ½	Saltcake	S96T003758 S96T003760 S96T003764 S96T003766 S96T003768	Density DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)
3	Liner Liquid	Liquid	S96T003933 S96T003934	IC, ICP Archive
	Upper ½	Saltcake	S96T003918 S96T003924 S96T003937 S96T003943 S96T003949	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)
	Lower ½	Saltcake	S96T003919 S96T003925 S96T003938 S96T003944 S96T003950 S96T003957	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest) ICP (water digest)
3A	Lower ½	Saltcake	S96T003920 S96T003926 S96T003939 S96T003945 S96T003951 S96T003930	Density DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest) ICP (water digest)

Table B2-3. Summary of Samples and Analyses. (Fritts 1996a) (4 sheets)

Segment	Segment Portion	Waste Matrix	Sample Number	Analyses
4	Lower ½	Saltcake	S96T003921 S96T003927 S96T003940 S96T003946 S96T003952 S96T003931	Density DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest) Archive
Core 160				
1	Lower ½	Saltcake	S96T003769 S96T003800 S96T003815 S96T003818 S96T003820 S96T003809	Density DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest) Archive
2	Lower ½	Saltcake	S96T003770 S96T003801 S96T003814 S96T003819 S96T003821 S96T003823 S96T003813	Density DSC, TGA, TIC/TOC Fusion Alpha, Beta, GEA, ^{90}Sr, U ICP (acid digest) IC (water digest) ICP (water digest) Archive
2A	Liner Liquid	Liquid	S96T003825 S96T003826	IC, ICP Archive
	Lower ½	Saltcake	S96T003839 S96T003840 S96T003841 S96T003842	DSC, TGA, TIC/TOC Fusion Alpha, GEA IC (water digest) ICP (water digest)

Table B2-3. Summary of Samples and Analyses. (Fritts 1996a) (4 sheets)

Segment	Segment Portion	Waste Matrix	Sample Number	Analyses
2B	Liner Liquid	Liquid	S96T004026 S96T004027	IC, ICP Archive
	Upper ½	Saltcake	S96T004028 S96T004035 S96T004037 S96T004040 S96T004042	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)
	Lower ½	Saltcake	S96T004029 S96T004036 S96T004038 S96T004041 S96T004043	Density, Archive DSC, TGA, TIC/TOC Fusion Alpha, GEA ICP (acid digest) IC (water digest)
2C	Drainable	Liquid	S96T004033 S96T004032	Alpha, IC, ICP, DSC, TGA, SpG Archive

Note:

TIC = total inorganic carbon

B2.3 1996 PUSH CORE ANALYTICAL RESULTS

This section summarizes the sampling and analytical results associated with the June/July 1996 sampling and analysis of tank 241-S-109. The total alpha activity, percent water, energetics, IC, and ICP analytical results associated with this tank are presented in Table B2-4. These results are documented in Fritts (1996b).

Table B2-4. Analytical Presentation Tables.

Analysis	Table number
Total alpha activity	B2-60
Percent water	B2-57
Bulk density	B2-55
Differential scanning calorimetry	B2-56
Summary data for metals by ICP	B2-8 through B2-44
Anions by IC	B2-46 through B2-53
Uranium	B2-45
Radionuclides	B2-62 through 67
TOC/TIC	B2-54 and B2-68

The four QC parameters assessed in conjunction with the tank 241-S-109 samples were standard recoveries, spike recoveries, duplicate analyses (RPDs), and blanks. The QC criteria specified in the SAP (Field 1996) were 90 to 110 percent recovery for standards and spikes and ≤20 percent for RPDs. These criteria applied to all of the analytes. The only QC parameter for which limits are not specified in the SAP is blank contamination. The limits for blanks are set forth in guidelines followed by the laboratory, and all data results presented in this report have met those guidelines. Sample and duplicate pairs in which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following data summary tables with an "a," "b," "c," "d," or "e" as follows:

- "a" indicates that the standard recovery was below the QC limit.
- "b" indicates that the standard recovery was above the QC limit.
- "c" indicates that the spike recovery was below the QC limit.
- "d" indicates that the spike recovery was above the QC limit.
- "e" indicates that the RPD was above the QC limit.
- "f" indicates blank contamination.

B2.3.1 Total Alpha Activity

Total alpha analyses were performed on a fusion-digested sample with an alpha proportional counter following procedure LA-508-101, Rev. D-2. All total alpha results were well below the DQO notification limit of 40 μCi/g. The maximum total alpha activity result was 2.14 E-02 μCi/g (core 158, segment 1 lower half) with a upper limit to a 95-percent confidence interval of 2.80 E-02, indicating that the potential for a criticality event is extremely low for the samples recovered. Eight RPD values exceeded the upper limit by ±20 percent; however, no reruns were requested because all results were well below the notification limit.

B2.3.2 Thermodynamic Analyses

As required by the safety screening and historical DQOs, TGA, DSC and density were performed on the solids. No other physical tests were required or performed.

B2.3.2.1 Thermogravimetric Analyses. Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Nitrogen is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, either through evaporation or a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C) is caused by water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well.

Weight percent water by TGA was performed by the 222-S Laboratory under a nitrogen purge using procedures LA-560-112 and LA-514-114.

Solids results ranged from 1.28 to 23.09 weight percent water with an average of 7.3 percent. Drainable liquid results ranged from 46.27 to 54.22 weight percent water.

Although no strong trends were observed in the data, the tank appears to be substantially drier than predicted by Agnew et al. (1996).

B2.3.2.2 Differential Scanning Calorimetry. In a DSC analysis, heat absorbed or emitted by a substance is measured while the sample is heated at a constant rate. Nitrogen is passed over the sample to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically.

The DSC analyses were performed under a nitrogen atmosphere using procedure LA-514-113, Rev. C-1 and a Mettler™ Model 20 differential scanning calorimeter and procedure LA-514-114, Rev. C-1 and Perkin-Elmer™ equipment. No exotherms were observed in excess of the safety screening notification limits. However, small exotherms were observed in a few of the samples. No quality control problems were noted.

Generally, all of the exotherms observed were small and were observed at temperatures above 330 °C. These could represent additional reactions or a carryover of a reaction that started at a lower temperature and was masked by a concurrent endotherm. However, for exotherms of this magnitude, a more likely cause was a shift in the instrument baseline at higher temperatures. In these cases, the DSC may have indicated a response where none occurred, and observations could be artifacts of the analytical method.

The DSC results are reported on a wet-weight basis. The safety screening DQO, however, requires that the exothermic reactions be evaluated on a dry-weight basis to make a decision about tank safety. The dry-weight value is calculated from the wet-weight value by dividing the reported exothermic value for a subsegment by the solid fraction of the subsegment (that is, 1 minus the fractional percent water value for that subsegment). No exotherms were observed in the drainable liquid samples.

B2.3.2.3 Density. Density of solids and specific gravity of liquids were measured for all samples. The mean density for the samples taken was 1.30 g/mL, with a range of 1.19 to 1.73 g/mL. Because of the small samples collected, bulk density measurements could not be obtained for core 160, segment 2A. The mean density was used to calculate tank inventory for each analyte. The mean specific gravity for the drainable liquid sample was 1.37.

B2.3.3 Inductively Coupled Plasma

Samples were prepared by acid and water digest. The inductively coupled plasma (ICP) analyses were performed following procedures LA-505-161, Rev. B-1 or LA-505-151, Rev. D-3, depending on the ICP instrument used. Although a full suite of analyses were reported, only aluminum, sodium, chromium, and uranium were requested by the Historical DQO. If data for other metals are to be used, the quality control criteria and raw data should be evaluated. Only 13 of 36 ICP analytes were identified above detection limits. These were aluminum, boron, calcium, chromium, iron, lithium (from HHF fluid), manganese, phosphorous, silicon, silver, sodium, sulfur and zinc.

B2.3.4 Ion Chromatography

Samples for ion chromatography (IC) were prepared by water digest and performed in duplicate following procedure LA-533-105, Rev. D-1. Although a full suite of analytes is reported, analytes requested for the historical DQO were nitrate and carbonate. If data for other anions are to be used, the quality control criteria and raw data should be evaluated. All of the anions were above detection limits. The primary anion in all samples was nitrate.

B2.3.5 Radionuclides

Fission products (^{137}Cs, ^{60}Co, ^{154}Eu, and ^{155}Eu) were analyzed by GEA, total beta was measured by beta counting, and $^{89/90}$Sr was analyzed by beta counting following procedure LA-220-101. Only ^{137}Cs was detected by GEA analysis. It had a mean value of 7.97 μCi/g. Total beta and $^{89/90}$Sr were analyzed in segment 2, lower half, only. Total beta values ranged from 7.3 to 22.4 μCi/g, and $^{89/90}$Sr values ranged from 2.4 to 8.2 μCi/g.

B2.3.6 Total Inorganic Carbon and Total Organic Carbon

Total inorganic carbon and total organic carbon analyses were performed for all samples using persulfate oxidation. TOC values ranged from 215 to 1,855 μg/g. TIC values were higher, ranging from extreme values as high as 24,000 to as low as 306 μg/g. Most TIC values were between 1,000 and 7,000 μg/g.

B2.4 1996 VAPOR SAMPLE

On May 16, 1996, vapor phase measurements were taken from the domespace of riser 11. Results are included in Table B2-5.

On June 4, 1996 vapor samples were obtained from riser 11. Sampling and analysis were conducted in accordance with *Data Quality Objectives for Tank Hazardous Vapor Screening* (Osborne and Buckley 1995) and the vapor sampling and analysis plan (Homi 1996). Sorbent traps were analyzed for inorganic analytes by either selective electrode or ion chromatography. Tank headspace canister samples were analyzed for permanent gases using gas chromatography/thermal conductivity detection and for total nonmethane organic compounds using gas chromatography/flame ionization detection.

A summary of sample results is included in Table B2-5. Additional results are documented in Pool et al. (1996).

B2.5 DESCRIPTION OF HISTORICAL SAMPLING EVENTS

Because all supernatant has been removed from tank 241-S-109, supernatant analyses for samples obtained between 1971 and 1974 are not representative of current tank contents and are not presented in this report. Sources of information for these samples events are included in Appendix E.

Two 100-mL samples were obtained in October 1991 (Pitkoff 1991). The samples were taken from the bottom of the saltwell screen in tank 241-S-109 per procedure T0-080-030. Sample numbers were 9S1091 and 9S1091-R. Sample results are included in Table B2-6.

Table B2-5. Summary Results of Vapor Samples. (2 sheets)

Category	Sample Medium	Analyte	Vapor Concentration[a]	Units
Sniff test measurement	Not applicable	LFL	0	%
		O_2	20.8	%
		TOC	3	ppm
		NH_3	80	ppm
Inorganic analytes[1]	Sorbent traps	NH_3	44.9 ± 2.2	ppmv
		NO_2	< 0.16	ppmv
		NO	< 0.16	ppmv
		H_2O	10.8 ± 0.2	mg/L
Permanent gases	SUMMA™ canister	CO_2	< 17	ppmv
		CO	< 17	ppmv
		CH_4	< 25	ppmv
		H_2	< 17	ppmv
		N_2O	< 17	ppmv

Table B2-5. Summary Results of Vapor Samples. (2 sheets)

Category	Sample Medium	Analyte	Vapor Concentration[2]	Units
Total non-methane organic compounds (TO-12)	SUMMA™ canister		3.74	mg/m^3

Notes:

[1]Vapor concentrations were determined using sample-volume data provided by Westinghouse Hanford Company and are based on averaged data.

[2]Inorganic analyte concentrations are based on dry-tank air at standard temperature and pressure.

Table B2-6. Sample from Tank 241-S-109. (WHC 1991)

Waste Tank 241-S-109, Sample T-8598		
Physical Data		
Appearance	Yellow, Aqueous, <5% Solids	
Radiation	1200 mR/hr	
pH	13.220	
Chemical Analysis		
Component	Lab Value	Lab Unit
Al	0.984	moles/L
F	1.32×10^3	ppm
OH	2.652	moles/L
NO_2	0.967	moles/L
NO_3	1.8476×10^5	ppm
PO_4	1.990×10^{-2}	moles/L
SO_4	3.77×10^4	ppm
TIC	5.070	g/L
TOC	1.240	g/L
Radiological Analysis		
Component	Lab Value	Lab Unit
^{241}Am	0.146	$\mu Ci/L$
$^{239/240}Pu$	0.177	$\mu Ci/L$

October 29, 1976 saltcake sample results should be similar to the June/July 1996 core sample analyses. No information was available about how the sample was taken or from what area in the tank. Solids obtained were coarse, granular, yellowish crystals. The crystals were 85 to 90 percent water soluble. Salts were mostly sodium nitrate associated with interstitial liquor. Samples were prepared for analysis by weighing a known amount of solids, dissolving the solids in water, and diluting the solution to a known volume. The fraction not soluble in water was dissolved in concentrated HCl and diluted with water to a known volume. Results of the laboratory work are presented in Table B2-7. No quality control data were available for these sample results.

Table B2-7. Sample from Tank 241-S-109. (Horton 1976)[1]

Physical Data		
Component	**Lab Value**	**Lab Unit**
Bulk Density	1.27	g/cc
Particle Density	2.38	g/cc
Water Content	10.6	Weight Percent
Chemical Analysis		
Component	**Lab Value**	**Lab Unit**
AlO_2	1.3	Weight Percent
CO_3	4.2	Weight Percent
Fe	0.3	Weight Percent
OH	0.3	Weight Percent
NO_2	1.4	Weight Percent
NO_3	53.5	Weight Percent
Mn	0.003	Weight Percent
Mg	0.02	Weight Percent
Ca	0.08	Weight Percent
Cr	0.1	Weight Percent
Si	0.1	Weight Percent
Na	35.0	Weight Percent
PO_4	0.01	Weight Percent
SO_4	0.9	Weight Percent
Radiological Analysis		
Component	**Lab Value**	**Lab Unit**
Pu	0.654	μg/g
$^{89+90}Sr$	14.6	μCi/g
^{137}Cs	71.8	μCi/g

Note:

[1]Pre-May 1979 data; use with caution.

Table B2-8. Tank 241-S-109 Analytical Results: Aluminum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	2,800	2,410	2,605
S96T003941		Upper 1/2	5,690	5,630	5,660
S96T003752	158: 2	Lower 1/2	1,820	1,950	1,885
S96T003944	158: 3	Lower 1/2	1,040	1,050	1,045
S96T003943		Upper 1/2	628	483	555.5
S96T003946	158: 4	Lower 1/2	292	324	308
S96T004019	158:2A	Lower 1/2	919	1,160	1,039.5
S96T003766	158:2B	Lower 1/2	423	447	435
S96T003765		Upper 1/2	595	561	578
S96T003945	158:3A	Lower 1/2	414	440	427
S96T003818	160: 1	Lower 1/2	1,540	1,630	1,585
S96T003819	160: 2	Lower 1/2	454	413	433.5
S96T004041	160:2B	Lower 1/2	6,910	6,810	6,860
S96T004040		Upper 1/2	675	693	684
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	2,050	2,100	2,075
S96T003823	160: 2	Lower 1/2	88.2	66.6	77.4
S96T003842	160:2A	Lower 1/2	295	288	291.5
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	790	301	545.5[QC:c,e]

Table B2-9. Tank 241-S-109 Analytical Results: Antimony (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 36.3	< 36	< 36.15
S96T003941		Upper 1/2	< 34.4	< 34	< 34.2
S96T003752	158: 2	Lower 1/2	< 35.1	< 36.4	< 35.75
S96T003944	158: 3	Lower 1/2	< 37.8	< 34.8	< 36.3
S96T003943		Upper 1/2	< 35.2	< 37.6	< 36.4
S96T003946	158: 4	Lower 1/2	< 37.5	< 35.4	< 36.45
S96T004019	158:2A	Lower 1/2	< 35.1	< 33.2	< 34.15
S96T003766	158:2B	Lower 1/2	< 36.8	< 36.2	< 36.5
S96T003765		Upper 1/2	< 35	< 35.3	< 35.15
S96T003945	158:3A	Lower 1/2	< 35.3	< 34.4	< 34.85
S96T003818	160: 1	Lower 1/2	< 34	< 34.5	< 34.25
S96T003819	160: 2	Lower 1/2	< 36.3	< 36.1	< 36.2
S96T004041	160:2B	Lower 1/2	< 34.7	< 34.6	< 34.65
S96T004040		Upper 1/2	< 35.2	< 34.1	< 34.65
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 36.3	< 35.6	< 35.95
S96T003823	160: 2	Lower 1/2	< 38.5	< 37.1	< 37.8
S96T003842	160:2A	Lower 1/2	< 36.6	< 36.6	< 36.6
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 24.1	< 24.1	< 24.1

Table B2-10. Tank 241-S-109 Analytical Results: Arsenic (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-11. Tank 241-S-109 Analytical Results: Barium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 30.3	< 30	< 30.15
S96T003941		Upper 1/2	< 28.7	< 28.3	< 28.5
S96T003752	158: 2	Lower 1/2	< 29.2	< 30.4	< 29.8
S96T003944	158: 3	Lower 1/2	< 31.5	< 29	< 30.25
S96T003943		Upper 1/2	< 29.4	< 31.3	< 30.35
S96T003946	158: 4	Lower 1/2	< 31.3	< 29.5	< 30.4
S96T004019	158:2A	Lower 1/2	< 29.2	< 27.7	< 28.45
S96T003766	158:2B	Lower 1/2	< 30.7	< 30.2	< 30.45
S96T003765		Upper 1/2	< 29.2	< 29.4	< 29.3
S96T003945	158:3A	Lower 1/2	< 29.4	< 28.7	< 29.05
S96T003818	160: 1	Lower 1/2	< 28.4	< 28.7	< 28.55
S96T003819	160: 2	Lower 1/2	< 30.3	< 30.1	< 30.2
S96T004041	160:2B	Lower 1/2	< 28.9	< 28.8	< 28.85
S96T004040		Upper 1/2	< 29.4	< 28.4	< 28.9
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 30.2	< 29.7	< 29.95
S96T003823	160: 2	Lower 1/2	< 32.1	< 30.9	< 31.5
S96T003842	160:2A	Lower 1/2	< 30.5	< 30.5	< 30.5
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 20.1	< 20.1	< 20.1

Table B2-12. Tank 241-S-109 Analytical Results: Beryllium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 3.03	< 3	< 3.015
S96T003941		Upper 1/2	< 2.87	< 2.83	< 2.85
S96T003752	158: 2	Lower 1/2	< 2.92	< 3.04	< 2.98
S96T003944	158: 3	Lower 1/2	< 3.15	< 2.9	< 3.025
S96T003943		Upper 1/2	< 2.94	< 3.13	< 3.035
S96T003946	158: 4	Lower 1/2	< 3.13	< 2.95	< 3.04
S96T004019	158:2A	Lower 1/2	< 2.92	< 2.77	< 2.845
S96T003766	158:2B	Lower 1/2	< 3.07	< 3.02	< 3.045
S96T003765		Upper 1/2	< 2.92	< 2.94	< 2.93
S96T003945	158:3A	Lower 1/2	< 2.94	< 2.87	< 2.905
S96T003818	160: 1	Lower 1/2	< 2.84	< 2.87	< 2.855
S96T003819	160: 2	Lower 1/2	< 3.03	< 3.01	< 3.02
S96T004041	160:2B	Lower 1/2	< 2.89	< 2.88	< 2.885
S96T004040		Upper 1/2	< 2.94	< 2.84	< 2.89
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 3.02	< 2.97	< 2.995
S96T003823	160: 2	Lower 1/2	< 3.21	< 3.09	< 3.15
S96T003842	160:2A	Lower 1/2	< 3.05	< 3.05	< 3.05
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 2	< 2	< 2

Table B2-13. Tank 241-S-109 Analytical Results: Bismuth (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-14. Tank 241-S-109 Analytical Results: Boron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	45.4	93.6	69.5
S96T003941		Upper 1/2	< 28.7	90.2	< 59.45
S96T003752	158: 2	Lower 1/2	106	101	103.5
S96T003944	158: 3	Lower 1/2	< 31.5	30.7	< 31.1
S96T003943		Upper 1/2	< 29.4	53.9	< 41.65
S96T003946	158: 4	Lower 1/2	< 31.3	29.7	< 30.5
S96T004019	158:2A	Lower 1/2	< 29.2	43.1	< 36.15
S96T003766	158:2B	Lower 1/2	80	61.3	70.65
S96T003765		Upper 1/2	90.8	85.5	88.15
S96T003945	158:3A	Lower 1/2	< 29.4	33.1	< 31.25
S96T003818	160: 1	Lower 1/2	< 28.4	46.6	< 37.5
S96T003819	160: 2	Lower 1/2	40.9	88.5	64.7
S96T004041	160:2B	Lower 1/2	32.4	57.3	44.85
S96T004040		Upper 1/2	68.6	39.3	53.95
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	518	458	488
S96T003823	160: 2	Lower 1/2	556	510	533
S96T003842	160:2A	Lower 1/2	461	554	507.5
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 20.1	< 20.1	< 20.1

Table B2-15. Tank 241-S-109 Analytical Results: Cadmium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 3.03	< 3	< 3.015
S96T003941		Upper 1/2	3.34	< 2.83	< 3.085
S96T003752	158: 2	Lower 1/2	< 2.92	< 3.04	< 2.98
S96T003944	158: 3	Lower 1/2	< 3.15	< 2.9	< 3.025
S96T003943		Upper 1/2	< 2.94	< 3.13	< 3.035
S96T003946	158: 4	Lower 1/2	< 3.13	< 2.95	< 3.04
S96T004019	158:2A	Lower 1/2	< 2.92	< 2.77	< 2.845
S96T003766	158:2B	Lower 1/2	< 3.07	< 3.02	< 3.045
S96T003765		Upper 1/2	< 2.92	< 2.94	< 2.93
S96T003945	158:3A	Lower 1/2	< 2.94	< 2.87	< 2.905
S96T003818	160: 1	Lower 1/2	< 2.84	< 2.87	< 2.855
S96T003819	160: 2	Lower 1/2	< 3.03	< 3.01	< 3.02
S96T004041	160:2B	Lower 1/2	3.42	3.69	3.555
S96T004040		Upper 1/2	< 2.94	< 2.84	< 2.89
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 3.02	< 2.97	< 2.995
S96T003823	160: 2	Lower 1/2	< 3.21	< 3.09	< 3.15
S96T003842	160:2A	Lower 1/2	< 3.05	< 3.05	< 3.05
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 2	< 2	< 2

Table B2-16. Tank 241-S-109 Analytical Results: Calcium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	103	104	103.5
S96T003941		Upper 1/2	223	250	236.5
S96T003752	158: 2	Lower 1/2	181	92.5	136.75
S96T003944	158: 3	Lower 1/2	105	85	95
S96T003943		Upper 1/2	74.3	< 62.6	< 68.45
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	67.1	96.1	81.6
S96T003766	158:2B	Lower 1/2	66.3	118	92.15
S96T003765		Upper 1/2	71.4	98.2	84.8
S96T003945	158:3A	Lower 1/2	< 58.8	88.6	< 73.7
S96T003818	160: 1	Lower 1/2	109	61.9	85.45[QC:c]
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	168	161	164.5
S96T004040		Upper 1/2	66	78.7	72.35
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	56.9	< 40.1	< 48.5[QC:e]

Table B2-17. Tank 241-S-109 Analytical Results: Cerium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-18. Tank 241-S-109 Analytical Results: Chromium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	1,550	1,530	1,540
S96T003941		Upper 1/2	4,830	4,740	4,785
S96T003752	158: 2	Lower 1/2	603	662	632.5
S96T003944	158: 3	Lower 1/2	787	797	792
S96T003943		Upper 1/2	1,030	1,190	1,110
S96T003946	158: 4	Lower 1/2	186	211	198.5
S96T004019	158:2A	Lower 1/2	433	549	491
S96T003766	158:2B	Lower 1/2	668	693	680.5
S96T003765		Upper 1/2	1,930	1,770	1,850
S96T003945	158:3A	Lower 1/2	346	356	351
S96T003818	160: 1	Lower 1/2	1,600	1,680	1,640
S96T003819	160: 2	Lower 1/2	1,030	1,070	1,050
S96T004041	160:2B	Lower 1/2	3,950	4,080	4,015
S96T004040		Upper 1/2	888	916	902
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	580	589	584.5
S96T003823	160: 2	Lower 1/2	277	214	245.5
S96T003842	160:2A	Lower 1/2	1,990	1,980	1,985
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	2,320	1,910	2,115[QC:c]

Table B2-19. Tank 241-S-109 Analytical Results: Cobalt (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 12.1	< 12	< 12.05
S96T003941		Upper 1/2	< 11.5	< 11.3	< 11.4
S96T003752	158: 2	Lower 1/2	< 11.7	< 12.1	< 11.9
S96T003944	158: 3	Lower 1/2	< 12.6	< 11.6	< 12.1
S96T003943		Upper 1/2	< 11.7	< 12.5	< 12.1
S96T003946	158: 4	Lower 1/2	< 12.5	< 11.8	< 12.15
S96T004019	158:2A	Lower 1/2	< 11.7	< 11.1	< 11.4
S96T003766	158:2B	Lower 1/2	< 12.3	< 12.1	< 12.2
S96T003765		Upper 1/2	< 11.7	< 11.8	< 11.75
S96T003945	158:3A	Lower 1/2	< 11.8	< 11.5	< 11.65
S96T003818	160: 1	Lower 1/2	< 11.3	< 11.5	< 11.4
S96T003819	160: 2	Lower 1/2	< 12.1	< 12	< 12.05
S96T004041	160:2B	Lower 1/2	< 11.6	< 11.5	< 11.55
S96T004040		Upper 1/2	< 11.7	< 11.4	< 11.55
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 12.1	< 11.9	< 12
S96T003823	160: 2	Lower 1/2	< 12.8	< 12.4	< 12.6
S96T003842	160:2A	Lower 1/2	< 12.2	< 12.2	< 12.2
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 8.02	< 8.02	< 8.02

Table B2-20. Tank 241-S-109 Analytical Results: Copper (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 6.05	< 5.99	< 6.02
S96T003941		Upper 1/2	< 5.74	< 5.66	< 5.7
S96T003752	158: 2	Lower 1/2	< 5.85	< 6.07	< 5.96
S96T003944	158: 3	Lower 1/2	< 6.31	< 5.8	< 6.055
S96T003943		Upper 1/2	8.44	< 6.26	< 7.35
S96T003946	158: 4	Lower 1/2	< 6.25	< 5.9	< 6.075
S96T004019	158:2A	Lower 1/2	< 5.84	< 5.54	< 5.69
S96T003766	158:2B	Lower 1/2	< 6.13	< 6.03	< 6.08
S96T003765		Upper 1/2	< 5.84	< 5.88	< 5.86
S96T003945	158:3A	Lower 1/2	< 5.88	< 5.74	< 5.81
S96T003818	160: 1	Lower 1/2	< 5.67	< 5.74	< 5.705
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	< 5.78	< 5.76	< 5.77
S96T004040		Upper 1/2	< 5.87	< 5.69	< 5.78
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	< 6.1	< 6.1	< 6.1
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 4.01	< 4.01	< 4.01

Table B2-21. Tank 241-S-109 Analytical Results: Iron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
S96T003942	158: 1	Lower 1/2	80	50.8	65.4
S96T003941		Upper 1/2	1,580	919	1,249.5
S96T003752	158: 2	Lower 1/2	51.7	51.9	51.8
S96T003944	158: 3	Lower 1/2	57.2	66.1	61.65
S96T003943		Upper 1/2	50.1	47.7	48.9
S96T003946	158: 4	Lower 1/2	89.4	72.3	80.85
S96T004019	158:2A	Lower 1/2	52.5	66.6	59.55
S96T003766	158:2B	Lower 1/2	< 30.7	31.6	< 31.15
S96T003765		Upper 1/2	55.7	39.6	47.65
S96T003945	158:3A	Lower 1/2	32.7	50.3	41.5
S96T003818	160: 1	Lower 1/2	9,400	2,230	5,815[QC:c]
S96T003819	160: 2	Lower 1/2	56.6	78.4	67.5
S96T004041	160:2B	Lower 1/2	197	150	173.5
S96T004040		Upper 1/2	40.6	38.2	39.4
Solids: water digest			μg/g	μg/g	μg/g
S96T003778	158: 2	Lower 1/2	< 30.2	< 29.7	< 29.95
S96T003823	160: 2	Lower 1/2	< 32.1	< 30.9	< 31.5
S96T003842	160:2A	Lower 1/2	< 30.5	< 30.5	< 30.5
Liquids			μg/mL	μg/mL	μg/mL
S96T004033	160:2C	DL	35.8	< 20.1	< 27.95[QC:e]

Table B2-22. Tank 241-S-109 Analytical Results: Lanthanum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 30.3	< 30	< 30.15
S96T003941		Upper 1/2	< 28.7	< 28.3	< 28.5
S96T003752	158: 2	Lower 1/2	< 29.2	< 30.4	< 29.8
S96T003944	158: 3	Lower 1/2	< 31.5	< 29	< 30.25
S96T003943		Upper 1/2	< 29.4	< 31.3	< 30.35
S96T003946	158: 4	Lower 1/2	< 31.3	< 29.5	< 30.4
S96T004019	158:2A	Lower 1/2	< 29.2	< 27.7	< 28.45
S96T003766	158:2B	Lower 1/2	< 30.7	< 30.2	< 30.45
S96T003765		Upper 1/2	< 29.2	< 29.4	< 29.3
S96T003945	158:3A	Lower 1/2	< 29.4	< 28.7	< 29.05
S96T003818	160: 1	Lower 1/2	< 28.4	< 28.7	< 28.55
S96T003819	160: 2	Lower 1/2	< 30.3	< 30.1	< 30.2
S96T004041	160:2B	Lower 1/2	< 28.9	< 28.8	< 28.85
S96T004040		Upper 1/2	< 29.4	< 28.4	< 28.9
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 30.2	< 29.7	< 29.95
S96T003823	160: 2	Lower 1/2	< 32.1	< 30.9	< 31.5
S96T003842	160:2A	Lower 1/2	< 30.5	< 30.5	< 30.5
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 20.1	< 20.1	< 20.1

Table B2-23. Tank 241-S-109 Analytical Results: Lead (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	71.3	< 60.3	< 65.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-24. Tank 241-S-109 Analytical Results: Lithium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 6.05	< 5.99	< 6.02
S96T003941		Upper 1/2	< 5.74	< 5.66	< 5.7
S96T003752	158: 2	Lower 1/2	11.6	13.7	12.65
S96T003944	158: 3	Lower 1/2	762	769	765.5
S96T003943		Upper 1/2	461	492	476.5
S96T003946	158: 4	Lower 1/2	581	677	629
S96T004019	158:2A	Lower 1/2	146	168	157
S96T003766	158:2B	Lower 1/2	271	269	270
S96T003765		Upper 1/2	258	239	248.5
S96T003945	158:3A	Lower 1/2	478	516	497
S96T003818	160: 1	Lower 1/2	< 5.67	< 5.74	< 5.705
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	358	352	355
S96T004040		Upper 1/2	190	190	190
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	15.5	11.9	13.7
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	267	142	204.5[QC:e]

Table B2-25. Tank 241-S-109 Analytical Results: Magnesium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-26. Tank 241-S-109 Analytical Results: Manganese (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	16	12	14
S96T003941		Upper 1/2	42.1	37.3	39.7
S96T003752	158: 2	Lower 1/2	10.4	11.1	10.75
S96T003944	158: 3	Lower 1/2	12.1	10.9	11.5
S96T003943		Upper 1/2	9.5	< 6.26	< 7.88
S96T003946	158: 4	Lower 1/2	13.7	14.7	14.2
S96T004019	158:2A	Lower 1/2	8.84	15	11.92
S96T003766	158:2B	Lower 1/2	< 6.13	< 6.03	< 6.08
S96T003765		Upper 1/2	5.87	< 5.88	< 5.875
S96T003945	158:3A	Lower 1/2	7.61	7.8	7.705
S96T003818	160: 1	Lower 1/2	92.9	24.3	58.6
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	31.2	28.7	29.95
S96T004040		Upper 1/2	6.89	6.67	6.78
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	< 6.1	< 6.1	< 6.1
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	9.89	< 4.01	< 6.95[QC:e]

Table B2-27. Tank 241-S-109 Analytical Results: Molybdenum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 30.3	< 30	< 30.15
S96T003941		Upper 1/2	< 28.7	< 28.3	< 28.5
S96T003752	158: 2	Lower 1/2	< 29.2	< 30.4	< 29.8
S96T003944	158: 3	Lower 1/2	< 31.5	< 29	< 30.25
S96T003943		Upper 1/2	< 29.4	< 31.3	< 30.35
S96T003946	158: 4	Lower 1/2	< 31.3	< 29.5	< 30.4
S96T004019	158:2A	Lower 1/2	< 29.2	< 27.7	< 28.45
S96T003766	158:2B	Lower 1/2	< 30.7	< 30.2	< 30.45
S96T003765		Upper 1/2	< 29.2	< 29.4	< 29.3
S96T003945	158:3A	Lower 1/2	< 29.4	< 28.7	< 29.05
S96T003818	160: 1	Lower 1/2	< 28.4	< 28.7	< 28.55
S96T003819	160: 2	Lower 1/2	< 30.3	< 30.1	< 30.2
S96T004041	160:2B	Lower 1/2	< 28.9	< 28.8	< 28.85
S96T004040		Upper 1/2	< 29.4	< 28.4	< 28.9
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 30.2	< 29.7	< 29.95
S96T003823	160: 2	Lower 1/2	< 32.1	< 30.9	< 31.5
S96T003842	160:2A	Lower 1/2	< 30.5	< 30.5	< 30.5
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 20.1	< 20.1	< 20.1

Table B2-28. Tank 241-S-109 Analytical Results: Neodymium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-29. Tank 241-S-109 Analytical Results: Nickel (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
S96T003942	158: 1	Lower 1/2	< 12.1	< 12	< 12.05
S96T003941		Upper 1/2	19.1	16.3	17.7
S96T003752	158: 2	Lower 1/2	< 11.7	< 12.1	< 11.9
S96T003944	158: 3	Lower 1/2	< 12.6	< 11.6	< 12.1
S96T003943		Upper 1/2	< 11.7	< 12.5	< 12.1
S96T003946	158: 4	Lower 1/2	< 12.5	14.4	< 13.45
S96T004019	158:2A	Lower 1/2	< 11.7	12.9	< 12.3
S96T003766	158:2B	Lower 1/2	< 12.3	12.7	< 12.5
S96T003765		Upper 1/2	< 11.7	< 11.8	< 11.75
S96T003945	158:3A	Lower 1/2	< 11.8	< 11.5	< 11.65
S96T003818	160: 1	Lower 1/2	< 11.3	< 11.5	< 11.4
S96T003819	160: 2	Lower 1/2	< 12.1	< 12	< 12.05
S96T004041	160:2B	Lower 1/2	20.4	17.9	19.15
S96T004040		Upper 1/2	< 11.7	< 11.4	< 11.55
Solids: water digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
S96T003778	158: 2	Lower 1/2	< 12.1	< 11.9	< 12
S96T003823	160: 2	Lower 1/2	< 12.8	< 12.4	< 12.6
S96T003842	160:2A	Lower 1/2	< 12.2	< 12.2	< 12.2
Liquids			**$\mu g/mL$**	**$\mu g/mL$**	**$\mu g/mL$**
S96T004033	160:2C	DL	< 8.02	< 8.02	< 8.02

Table B2-30. Tank 241-S-109 Analytical Results: Phosphorus (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	2,560	2,270	2,415
S96T003941		Upper 1/2	13,200	12,800	13,000
S96T003752	158: 2	Lower 1/2	467	632	549.5
S96T003944	158: 3	Lower 1/2	2,720	2,920	2,820
S96T003943		Upper 1/2	2,710	3,240	2,975
S96T003946	158: 4	Lower 1/2	1,780	1,960	1,870
S96T004019	158:2A	Lower 1/2	798	750	774
S96T003766	158:2B	Lower 1/2	2,980	3,050	3,015
S96T003765		Upper 1/2	4,840	4,640	4,740
S96T003945	158:3A	Lower 1/2	2,960	3,080	3,020
S96T003818	160: 1	Lower 1/2	3,390	3,490	3,440[QC:c]
S96T003819	160: 2	Lower 1/2	2,360	2,790	2,575[QC:c]
S96T004041	160:2B	Lower 1/2	9,550	10,100	9,825
S96T004040		Upper 1/2	1,560	1,360	1,460
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	873	1,740	1,306.5
S96T003823	160: 2	Lower 1/2	1,700	1,070	1,385
S96T003842	160:2A	Lower 1/2	9,500	9,360	9,430
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	3,070	2,860	2,965[QC:c]

Table B2-31. Tank 241-S-109 Analytical Results: Potassium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	322	320	321
S96T003941		Upper 1/2	489	416	452.5
S96T003752	158: 2	Lower 1/2	< 292	< 304	< 298
S96T003944	158: 3	Lower 1/2	< 315	< 290	< 302.5
S96T003943		Upper 1/2	< 294	< 313	< 303.5
S96T003946	158: 4	Lower 1/2	< 313	< 295	< 304
S96T004019	158:2A	Lower 1/2	< 292	345	< 318.5
S96T003766	158:2B	Lower 1/2	< 307	< 302	< 304.5
S96T003765		Upper 1/2	< 292	< 294	< 293
S96T003945	158:3A	Lower 1/2	< 294	< 287	< 290.5
S96T003818	160: 1	Lower 1/2	315	< 287	< 301[QC:c]
S96T003819	160: 2	Lower 1/2	< 303	< 301	< 302
S96T004041	160:2B	Lower 1/2	< 289	< 288	< 288.5
S96T004040		Upper 1/2	< 294	< 284	< 289
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	308	< 297	< 302.5
S96T003823	160: 2	Lower 1/2	< 321	321	< 321
S96T003842	160:2A	Lower 1/2	< 305	< 305	< 305
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	218	285	251.5[QC:e]

Table B2-32. Tank 241-S-109 Analytical Results: Samarium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-33. Tank 241-S-109 Analytical Results: Selenium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 60.5	< 59.9	< 60.2
S96T003941		Upper 1/2	< 57.4	< 56.6	< 57
S96T003752	158: 2	Lower 1/2	< 58.5	< 60.7	< 59.6
S96T003944	158: 3	Lower 1/2	< 63.1	< 58	< 60.55
S96T003943		Upper 1/2	< 58.7	< 62.6	< 60.65
S96T003946	158: 4	Lower 1/2	< 62.5	< 59	< 60.75
S96T004019	158:2A	Lower 1/2	< 58.4	< 55.4	< 56.9
S96T003766	158:2B	Lower 1/2	< 61.3	< 60.3	< 60.8
S96T003765		Upper 1/2	< 58.4	< 58.8	< 58.6
S96T003945	158:3A	Lower 1/2	< 58.8	< 57.4	< 58.1
S96T003818	160: 1	Lower 1/2	< 56.7	< 57.4	< 57.05
S96T003819	160: 2	Lower 1/2	< 60.5	< 60.2	< 60.35
S96T004041	160:2B	Lower 1/2	< 57.8	< 57.6	< 57.7
S96T004040		Upper 1/2	< 58.7	< 56.9	< 57.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 60.5	< 59.3	< 59.9
S96T003823	160: 2	Lower 1/2	< 64.1	< 61.8	< 62.95
S96T003842	160:2A	Lower 1/2	< 61	< 61	< 61
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 40.1	< 40.1	< 40.1

Table B2-34. Tank 241-S-109 Analytical Results: Silicon (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	171	298	234.5
S96T003941		Upper 1/2	66	113	89.5
S96T003752	158: 2	Lower 1/2	136	176	156
S96T003944	158: 3	Lower 1/2	370	298	334
S96T003943		Upper 1/2	38.3	48.2	43.25
S96T003946	158: 4	Lower 1/2	296	386	341
S96T004019	158:2A	Lower 1/2	453	436	444.5
S96T003766	158:2B	Lower 1/2	104	96.4	100.2
S96T003765		Upper 1/2	229	200	214.5
S96T003945	158:3A	Lower 1/2	229	237	233
S96T003818	160: 1	Lower 1/2	541	817	679
S96T003819	160: 2	Lower 1/2	663	616	639.5
S96T004041	160:2B	Lower 1/2	405	314	359.5
S96T004040		Upper 1/2	573	750	661.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	405	361	383
S96T003823	160: 2	Lower 1/2	200	176	188
S96T003842	160:2A	Lower 1/2	360	438	399
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	222	99.7	160.85[QC:e]

Table B2-35. Tank 241-S-109 Analytical Results: Silver (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	17.1	16.5	16.8
S96T003941		Upper 1/2	16.3	15.4	15.85
S96T003752	158: 2	Lower 1/2	17.9	17.8	17.85
S96T003944	158: 3	Lower 1/2	16.3	16	16.15
S96T003943		Upper 1/2	17.1	17.4	17.25
S96T003946	158: 4	Lower 1/2	16.6	17.1	16.85
S96T004019	158:2A	Lower 1/2	16.6	16.8	16.7
S96T003766	158:2B	Lower 1/2	16.4	15.6	16
S96T003765		Upper 1/2	16.1	16.6	16.35
S96T003945	158:3A	Lower 1/2	16.3	17.3	16.8
S96T003818	160: 1	Lower 1/2	15.1	16.2	15.65
S96T003819	160: 2	Lower 1/2	17.5	16.9	17.2
S96T004041	160:2B	Lower 1/2	15.2	14.6	14.9
S96T004040		Upper 1/2	16.1	15.9	16
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	18.7	17.7	18.2
S96T003823	160: 2	Lower 1/2	18.7	17.5	18.1
S96T003842	160:2A	Lower 1/2	17.2	16.6	16.9
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	14.1	14	14.05

Table B2-36. Tank 241-S-109 Analytical Results: Sodium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower ½	2.440E+05	2.400E+05	2.420E+05
S96T003941		Upper ½	2.320E+05	2.260E+05	2.290E+05
S96T003752	158: 2	Lower ½	2.520E+05	2.530E+05	2.525E+05[QC:c]
S96T003944	158: 3	Lower 1/2	2.330E+05	2.310E+05	2.320E+05
S96T003943		Upper 1/2	2.450E+05	2.470E+05	2.460E+05[QC:c]
S96T003946	158: 4	Lower 1/2	2.420E+05	2.370E+05	2.395E+05[QC:d]
S96T004019	158:2A	Lower 1/2	2.410E+05	2.410E+05	2.410E+05
S96T003766	158:2B	Lower 1/2	2.300E+05	2.310E+05	2.305E+05
S96T003765		Upper 1/2	2.370E+05	2.330E+05	2.350E+05
S96T003945	158:3A	Lower 1/2	2.350E+05	2.360E+05	2.355E+05[QC:c]
S96T003818	160: 1	Lower 1/2	2.390E+05	2.400E+05	2.395E+05[QC:c]
S96T003819	160: 2	Lower 1/2	2.490E+05	2.450E+05	2.470E+05[QC:d]
S96T004041	160:2B	Lower 1/2	2.110E+05	2.100E+05	2.105E+05
S96T004040		Upper 1/2	2.300E+05	2.320E+05	2.310E+05
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower ½	2.650E+05	2.570E+05	2.610E+05[QC:c]
S96T003823	160: 2	Lower 1/2	2.580E+05	2.550E+05	2.565E+05[QC:c]
S96T003842	160:2A	Lower 1/2	2.480E+05	2.410E+05	2.445E+05[QC:c]
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	1.880E+05	1.870E+05	1.875E+05[QC:d]

Table B2-37. Tank 241-S-109 Analytical Results: Strontium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 6.05	< 5.99	< 6.02
S96T003941		Upper 1/2	< 5.74	< 5.66	< 5.7
S96T003752	158: 2	Lower 1/2	< 5.85	< 6.07	< 5.96
S96T003944	158: 3	Lower 1/2	< 6.31	< 5.8	< 6.055
S96T003943		Upper 1/2	< 5.87	< 6.26	< 6.065
S96T003946	158: 4	Lower 1/2	< 6.25	< 5.9	< 6.075
S96T004019	158:2A	Lower 1/2	< 5.84	< 5.54	< 5.69
S96T003766	158:2B	Lower 1/2	< 6.13	< 6.03	< 6.08
S96T003765		Upper 1/2	< 5.84	< 5.88	< 5.86
S96T003945	158:3A	Lower 1/2	< 5.88	< 5.74	< 5.81
S96T003818	160: 1	Lower 1/2	< 5.67	< 5.74	< 5.705
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	< 5.78	< 5.76	< 5.77
S96T004040		Upper 1/2	< 5.87	< 5.69	< 5.78
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	< 6.1	< 6.1	< 6.1
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 4.01	< 4.01	< 4.01

Table B2-38. Tank 241-S-109 Analytical Results: Sulfur (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**μg/g**	**μg/g**	**μg/g**
S96T003942	158: 1	Lower 1/2	6,730	4,820	5,775
S96T003941		Upper 1/2	10,700	12,500	11,600
S96T003752	158: 2	Lower 1/2	3,450	3,740	3,595
S96T003944	158: 3	Lower 1/2	2,570	2,050	2,310
S96T003943		Upper 1/2	1,690	400	1,045
S96T003946	158: 4	Lower 1/2	82.3	77.5	79.9
S96T004019	158:2A	Lower 1/2	2,690	5,090	3,890
S96T003766	158:2B	Lower 1/2	951	973	962
S96T003765		Upper 1/2	1,230	1,140	1,185
S96T003945	158:3A	Lower 1/2	916	939	927.5
S96T003818	160: 1	Lower 1/2	1,430	1,480	1,455[QC:c]
S96T003819	160: 2	Lower 1/2	938	874	906
S96T004041	160:2B	Lower 1/2	1,600	1,650	1,625
S96T004040		Upper 1/2	1,060	1,100	1,080
Solids: water digest			**μg/g**	**μg/g**	**μg/g**
S96T003778	158: 2	Lower 1/2	4,420	4,550	4,485
S96T003823	160: 2	Lower 1/2	1,080	676	878
S96T003842	160:2A	Lower 1/2	634	567	600.5
Liquids			**μg/mL**	**μg/mL**	**μg/mL**
S96T004033	160:2C	DL	3,590	3,630	3,610

Table B2-39. Tank 241-S-109 Analytical Results: Thallium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 121	< 120	< 120.5
S96T003941		Upper 1/2	< 115	< 113	< 114
S96T003752	158: 2	Lower 1/2	< 117	< 121	< 119
S96T003944	158: 3	Lower 1/2	< 126	< 116	< 121
S96T003943		Upper 1/2	< 117	< 125	< 121
S96T003946	158: 4	Lower 1/2	< 125	< 118	< 121.5
S96T004019	158:2A	Lower 1/2	< 117	< 111	< 114
S96T003766	158:2B	Lower 1/2	< 123	< 121	< 122
S96T003765		Upper 1/2	< 117	< 118	< 117.5
S96T003945	158:3A	Lower 1/2	< 118	< 115	< 116.5
S96T003818	160: 1	Lower 1/2	< 113	< 115	< 114
S96T003819	160: 2	Lower 1/2	< 121	< 120	< 120.5
S96T004041	160:2B	Lower 1/2	< 116	< 115	< 115.5
S96T004040		Upper 1/2	< 117	< 114	< 115.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 121	< 119	< 120
S96T003823	160: 2	Lower 1/2	< 128	< 124	< 126
S96T003842	160:2A	Lower 1/2	< 122	< 122	< 122
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 80.2	< 80.2	< 80.2

Table B2-40. Tank 241-S-109 Analytical Results: Titanium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 6.05	< 5.99	< 6.02
S96T003941		Upper 1/2	< 5.74	< 5.66	< 5.7
S96T003752	158: 2	Lower 1/2	< 5.85	< 6.07	< 5.96
S96T003944	158: 3	Lower 1/2	< 6.31	< 5.8	< 6.055
S96T003943		Upper 1/2	< 5.87	< 6.26	< 6.065
S96T003946	158: 4	Lower 1/2	< 6.25	< 5.9	< 6.075
S96T004019	158:2A	Lower 1/2	< 5.84	5.84	< 5.84
S96T003766	158:2B	Lower 1/2	< 6.13	< 6.03	< 6.08
S96T003765		Upper 1/2	< 5.84	< 5.88	< 5.86
S96T003945	158:3A	Lower 1/2	< 5.88	< 5.74	< 5.81
S96T003818	160: 1	Lower 1/2	< 5.67	< 5.74	< 5.705
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	< 5.78	< 5.76	< 5.77
S96T004040		Upper 1/2	< 5.87	< 5.69	< 5.78
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	< 6.1	< 6.1	< 6.1
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 4.01	< 4.01	< 4.01

Table B2-41. Tank 241-S-109 Analytical Results: Total Uranium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 303	< 300	< 301.5
S96T003941		Upper 1/2	< 287	293	< 290
S96T003752	158: 2	Lower 1/2	< 292	< 304	< 298
S96T003944	158: 3	Lower 1/2	< 315	< 290	< 302.5
S96T003943		Upper 1/2	< 294	< 313	< 303.5
S96T003946	158: 4	Lower 1/2	< 313	< 295	< 304
S96T004019	158:2A	Lower 1/2	< 292	< 277	< 284.5
S96T003766	158:2B	Lower 1/2	< 307	< 302	< 304.5
S96T003765		Upper 1/2	< 292	< 294	< 293
S96T003945	158:3A	Lower 1/2	< 294	< 287	< 290.5
S96T003818	160: 1	Lower 1/2	< 284	< 287	< 285.5
S96T003819	160: 2	Lower 1/2	< 303	< 301	< 302
S96T004041	160:2B	Lower 1/2	< 289	< 288	< 288.5
S96T004040		Upper 1/2	< 294	< 284	< 289
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 302	< 297	< 299.5
S96T003823	160: 2	Lower 1/2	< 321	< 309	< 315
S96T003842	160:2A	Lower 1/2	< 305	< 305	< 305
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 200	< 200	< 200

Table B2-42. Tank 241-S-109 Analytical Results: Vanadium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
S96T003942	158: 1	Lower 1/2	< 30.3	< 30	< 30.15
S96T003941		Upper 1/2	< 28.7	< 28.3	< 28.5
S96T003752	158: 2	Lower 1/2	< 29.2	< 30.4	< 29.8
S96T003944	158: 3	Lower 1/2	< 31.5	< 29	< 30.25
S96T003943		Upper 1/2	< 29.4	< 31.3	< 30.35
S96T003946	158: 4	Lower 1/2	< 31.3	< 29.5	< 30.4
S96T004019	158:2A	Lower 1/2	< 29.2	< 27.7	< 28.45
S96T003766	158:2B	Lower 1/2	< 30.7	< 30.2	< 30.45
S96T003765		Upper 1/2	< 29.2	< 29.4	< 29.3
S96T003945	158:3A	Lower 1/2	< 29.4	< 28.7	< 29.05
S96T003818	160: 1	Lower 1/2	< 28.4	< 28.7	< 28.55
S96T003819	160: 2	Lower 1/2	< 30.3	< 30.1	< 30.2
S96T004041	160:2B	Lower 1/2	< 28.9	< 28.8	< 28.85
S96T004040		Upper 1/2	< 29.4	< 28.4	< 28.9
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S96T003778	158: 2	Lower 1/2	< 30.2	< 29.7	< 29.95
S96T003823	160: 2	Lower 1/2	< 32.1	< 30.9	< 31.5
S96T003842	160:2A	Lower 1/2	< 30.5	< 30.5	< 30.5
Liquids			**µg/mL**	**µg/mL**	**µg/mL**
S96T004033	160:2C	DL	< 20.1	< 20.1	< 20.1

Table B2-43. Tank 241-S-109 Analytical Results: Zinc (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	19.8	20.1	19.95
S96T003941		Upper 1/2	21.8	19.6	20.7
S96T003752	158: 2	Lower 1/2	18.1	16.4	17.25
S96T003944	158: 3	Lower 1/2	24.3	18.3	21.3
S96T003943		Upper 1/2	23.1	19.1	21.1
S96T003946	158: 4	Lower 1/2	15.7	16.6	16.15
S96T004019	158:2A	Lower 1/2	20.1	21	20.55
S96T003766	158:2B	Lower 1/2	23	24.3	23.65
S96T003765		Upper 1/2	17.4	19.5	18.45
S96T003945	158:3A	Lower 1/2	13.6	15.8	14.7
S96T003818	160: 1	Lower 1/2	18.3	16.8	17.55
S96T003819	160: 2	Lower 1/2	16.3	14.7	15.5
S96T004041	160:2B	Lower 1/2	19.3	37	28.15
S96T004040		Upper 1/2	25.1	15.4	20.25
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	12.5	11	11.75
S96T003823	160: 2	Lower 1/2	13.9	11.2	12.55
S96T003842	160:2A	Lower 1/2	11.9	10.8	11.35
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	19.3	17.6	18.45

Table B2-44. Tank 241-S-109 Analytical Results: Zirconium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003942	158: 1	Lower 1/2	< 6.05	< 5.99	< 6.02
S96T003941		Upper 1/2	8.67	10.4	9.535
S96T003752	158: 2	Lower 1/2	< 5.85	< 6.07	< 5.96
S96T003944	158: 3	Lower 1/2	< 6.31	< 5.8	< 6.055
S96T003943		Upper 1/2	< 5.87	< 6.26	< 6.065
S96T003946	158: 4	Lower 1/2	< 6.25	< 5.9	< 6.075
S96T004019	158:2A	Lower 1/2	< 5.84	8.78	< 7.31
S96T003766	158:2B	Lower 1/2	< 6.13	< 6.03	< 6.08
S96T003765		Upper 1/2	< 5.84	< 5.88	< 5.86
S96T003945	158:3A	Lower 1/2	< 5.88	< 5.74	< 5.81
S96T003818	160: 1	Lower 1/2	< 5.67	< 5.74	< 5.705
S96T003819	160: 2	Lower 1/2	< 6.05	< 6.02	< 6.035
S96T004041	160:2B	Lower 1/2	13.3	14.5	13.9
S96T004040		Upper 1/2	< 5.87	< 5.69	< 5.78
Solids: water digest			µg/g	µg/g	µg/g
S96T003778	158: 2	Lower 1/2	< 6.05	< 5.93	< 5.99
S96T003823	160: 2	Lower 1/2	< 6.41	< 6.18	< 6.295
S96T003842	160:2A	Lower 1/2	< 6.1	< 6.1	< 6.1
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 4.01	< 4.01	< 4.01

Table B2-45. Tank 241-S-109 Analytical Results: Total Uranium (U).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S96T003737	158: 2	Lower 1/2	85.9	105	95.45
S96T003814	160: 2	Lower 1/2	20.5	21.5	21

Table B2-46. Tank 241-S-109 Analytical Results: Bromide (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S96T003948	158: 1	Lower 1/2	< 2,505	< 2,480	< 2,492.5
S96T003947		Upper 1/2	< 1,035	< 1,060	< 1,047.5
S96T003753	158: 2	Lower 1/2	< 1,739	< 1,740	< 1,739.5
S96T003950	158: 3	Lower 1/2	1,501	1,410	1,455.5
S96T003949		Upper 1/2	< 2,594	< 2,650	< 2,622
S96T003952	158: 4	Lower 1/2	1,033	1,380	1,206.5[QC:e]
S96T004020	158:2A	Lower 1/2	2,748	2,960	2,854
S96T003768	158:2B	Lower 1/2	2,774	2,810	2,792
S96T003767		Upper 1/2	2,095	2,150	2,122.5
S96T003951	158:3A	Lower 1/2	< 966.7	1,380	< 1,173.35[QC:e]
S96T003820	160: 1	Lower 1/2	< 1,297	< 1,270	< 1,283.5
S96T003821	160: 2	Lower 1/2	< 1,338	< 1,290	< 1,314
S96T003841	160:2A	Lower 1/2	< 1,023	< 1,020	< 1,021.5
S96T004043	160:2B	Lower 1/2	1,983	2,200	2,091.5
S96T004042		Upper 1/2	< 1,017	< 1,030	< 1,023.5
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	3,672	3,410	3,541

Table B2-47. Tank 241-S-109 Analytical Results: Chloride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S96T003948	158: 1	Lower 1/2	< 338	745	< 541.5[QC:e]
S96T003947		Upper 1/2	1,127	1,180	1,153.5
S96T003753	158: 2	Lower 1/2	625	549	587
S96T003950	158: 3	Lower 1/2	< 145.1	166	< 155.55
S96T003949		Upper 1/2	< 350.1	< 357	< 353.55
S96T003952	158: 4	Lower 1/2	< 130	< 155	< 142.5
S96T004020	158:2A	Lower 1/2	< 349.7	403	< 376.35
S96T003768	158:2B	Lower 1/2	< 373.1	< 371	< 372.05
S96T003767		Upper 1/2	< 238.6	< 237	< 237.8
S96T003951	158:3A	Lower 1/2	< 130.4	241	< 185.7[QC:e]
S96T003820	160: 1	Lower 1/2	470.6	427	448.8
S96T003821	160: 2	Lower 1/2	305.9	< 174	< 239.95[QC:d,e]
S96T003841	160:2A	Lower 1/2	423.6	212	317.8[QC:e]
S96T004043	160:2B	Lower 1/2	245.5	268	256.75
S96T004042		Upper 1/2	191.5	< 138	< 164.75[QC:e]
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	175.9	224	199.95

Table B2-48. Tank 241-S-109 Analytical Results: Fluoride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S96T003948	158: 1	Lower 1/2	< 258.5	< 256	< 257.25
S96T003947		Upper 1/2	346.1	331	338.55
S96T003753	158: 2	Lower 1/2	< 179.4	< 179	< 179.2
S96T003950	158: 3	Lower 1/2	< 110.9	< 112	< 111.45
S96T003949		Upper 1/2	< 267.7	< 273	< 270.35
S96T003952	158: 4	Lower 1/2	< 99.42	< 118	< 108.71
S96T004020	158:2A	Lower 1/2	< 267.4	< 261	< 264.2
S96T003768	158:2B	Lower 1/2	< 285.3	< 284	< 284.65
S96T003767		Upper 1/2	< 182.5	< 181	< 181.75
S96T003951	158:3A	Lower 1/2	< 99.74	< 114	< 106.87
S96T003820	160: 1	Lower 1/2	226.8	295	260.9[QC:e]
S96T003821	160: 2	Lower 1/2	< 138	< 133	< 135.5
S96T003841	160:2A	Lower 1/2	< 105.5	< 106	< 105.75
S96T004043	160:2B	Lower 1/2	624	673	648.5
S96T004042		Upper 1/2	< 104.9	< 106	< 105.45
Liquids			μg/mL	μg/mL	μg/mL
S96T004033	160:2C	DL	< 132.6	< 133	< 132.8

Table B2-49. Tank 241-S-109 Analytical Results: Nitrate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S96T003948	158: 1	Lower 1/2	6.171E+05	6.040E+05	6.106E+05
S96T003947		Upper 1/2	2.399E+05	2.270E+05	2.335E+05
S96T003753	158: 2	Lower 1/2	5.867E+05	5.890E+05	5.879E+05
S96T003950	158: 3	Lower 1/2	5.988E+05	6.320E+05	6.154E+05
S96T003949		Upper 1/2	6.760E+05	6.690E+05	6.725E+05
S96T003952	158: 4	Lower 1/2	6.822E+05	6.880E+05	6.851E+05
S96T004020	158:2A	Lower 1/2	6.076E+05	6.080E+05	6.078E+05[QC:c]
S96T003768	158:2B	Lower 1/2	6.097E+05	6.240E+05	6.169E+05
S96T003767		Upper 1/2	6.071E+05	6.000E+05	6.036E+05
S96T003951	158:3A	Lower 1/2	6.768E+05	6.530E+05	6.649E+05
S96T003820	160: 1	Lower 1/2	6.943E+05	6.730E+05	6.837E+05
S96T003821	160: 2	Lower 1/2	7.203E+05	7.420E+05	7.312E+05
S96T003841	160:2A	Lower 1/2	6.160E+05	6.090E+05	6.125E+05
S96T004043	160:2B	Lower 1/2	4.892E+05	4.640E+05	4.766E+05
S96T004042		Upper 1/2	6.702E+05	6.700E+05	6.701E+05
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	5.065E+05	6.020E+05	5.543E+05[QC:c]

Table B2-50. Tank 241-S-109 Analytical Results: Nitrite (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S96T003948	158: 1	Lower 1/2	< 2,127	8,270	< 5,198.5[QC:e]
S96T003947		Upper 1/2	9,304	9,780	9,542
S96T003753	158: 2	Lower 1/2	7,227	6,880	7,053.5
S96T003950	158: 3	Lower 1/2	3,626	3,650	3,638
S96T003949		Upper 1/2	4,668	4,810	4,739
S96T003952	158: 4	Lower 1/2	2,897	3,080	2,988.5
S96T004020	158:2A	Lower 1/2	5,391	5,590	5,490.5
S96T003768	158:2B	Lower 1/2	4,697	4,990	4,843.5
S96T003767		Upper 1/2	3,885	3,950	3,917.5
S96T003951	158:3A	Lower 1/2	3,177	3,350	3,263.5
S96T003820	160: 1	Lower 1/2	5,068	4,770	4,919
S96T003821	160: 2	Lower 1/2	3,837	3,590	3,713.5
S96T003841	160:2A	Lower 1/2	3,412	3,430	3,421
S96T004043	160:2B	Lower 1/2	3,628	3,420	3,524
S96T004042		Upper 1/2	2,932	3,190	3,061
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	3,249	3,220	3,234.5

Table B2-51. Tank 241-S-109 Analytical Results: Phosphate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S96T003948	158: 1	Lower 1/2	6,500	7,580	7,040
S96T003947		Upper 1/2	47,910	41,600	44,755
S96T003753	158: 2	Lower 1/2	2,196	< 1,640	< 1,918[QC:e]
S96T003950	158: 3	Lower 1/2	9,585	8,790	9,187.5
S96T003949		Upper 1/2	9,230	8,760	8,995
S96T003952	158: 4	Lower 1/2	4,935	5,330	5,132.5
S96T004020	158:2A	Lower 1/2	3,567	2,650	3,108.5[QC:e]
S96T003768	158:2B	Lower 1/2	7,130	8,930	8,030[QC:e]
S96T003767		Upper 1/2	11,910	12,400	12,155
S96T003951	158:3A	Lower 1/2	8,179	8,430	8,304.5
S96T003820	160: 1	Lower 1/2	11,080	10,400	10,740
S96T003821	160: 2	Lower 1/2	4,956	3,070	4,013[QC:e]
S96T003841	160:2A	Lower 1/2	27,190	26,700	26,945
S96T004043	160:2B	Lower 1/2	31,150	36,800	33,975
S96T004042		Upper 1/2	3,916	3,920	3,918
Liquids			μg/mL	μg/mL	μg/mL
S96T004033	160:2C	DL	3,055	2,700	2,877.5

Table B2-52. Tank 241-S-109 Analytical Results: Sulfate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S96T003948	158: 1	Lower 1/2	14,890	16,000	15,445
S96T003947		Upper 1/2	34,610	33,300	33,955
S96T003753	158: 2	Lower 1/2	14,790	12,600	13,695
S96T003950	158: 3	Lower 1/2	8,181	6,100	7,140.5[QC:e]
S96T003949		Upper 1/2	< 2,798	3,880	< 3,339[QC:e]
S96T003952	158: 4	Lower 1/2	< 1,039	< 1,240	< 1,139.5
S96T004020	158:2A	Lower 1/2	9,678	18,200	13,939[QC:e]
S96T003768	158:2B	Lower 1/2	3,670	3,860	3,765
S96T003767		Upper 1/2	4,191	4,010	4,100.5
S96T003951	158:3A	Lower 1/2	3,359	3,520	3,439.5
S96T003820	160: 1	Lower 1/2	6,549	5,220	5,884.5[QC:e]
S96T003821	160: 2	Lower 1/2	4,407	2,770	3,588.5[QC:e]
S96T003841	160:2A	Lower 1/2	2,463	2,120	2,291.5
S96T004043	160:2B	Lower 1/2	5,867	6,310	6,088.5
S96T004042		Upper 1/2	3,279	3,440	3,359.5
Liquids			μg/mL	μg/mL	μg/mL
S96T004033	160:2C	DL	4,712	4,810	4,761

Table B2-53. Tank 241-S-109 Analytical Results: Oxalate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S96T003948	158: 1	Lower 1/2	3,019	3,250	3,134.5
S96T003947		Upper 1/2	6,406	9,120	7,763[QC:e]
S96T003753	158: 2	Lower 1/2	2,914	2,700	2,807
S96T003950	158: 3	Lower 1/2	2,401	2,250	2,325.5
S96T003949		Upper 1/2	< 2,162	< 2,210	< 2,186
S96T003952	158: 4	Lower 1/2	2,395	2,580	2,487.5
S96T004020	158:2A	Lower 1/2	2,457	5,100	3,778.5[QC:e]
S96T003768	158:2B	Lower 1/2	< 2,304	< 2,290	< 2,297
S96T003767		Upper 1/2	< 1,474	1,530	< 1,502
S96T003951	158:3A	Lower 1/2	1,671	1,740	1,705.5
S96T003820	160: 1	Lower 1/2	1,339	1,590	1,464.5
S96T003821	160: 2	Lower 1/2	1,347	< 1,070	< 1,208.5[QC:e]
S96T003841	160:2A	Lower 1/2	859.5	1,190	1,024.75[QC:e]
S96T004043	160:2B	Lower 1/2	4,426	7,250	5,838[QC:e]
S96T004042		Upper 1/2	1,354	1,310	1,332
Liquids			µg/mL	µg/mL	µg/mL
S96T004033	160:2C	DL	< 1,071	< 1,070	< 1,070.5

Table B2-54. Tank 241-S-109 Analytical Results: Total Organic Carbon (TOC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Triplicate	Mean
Solids			µg/g	µg/g	µg/g	µg/g
S96T003923	158: 1	Lower 1/2	1,060	919		989.5
S96T003922		Upper 1/2	1,920	1,790		1,855
S96T003734	158: 2	Lower 1/2	775	816		795.5
S96T003925	158: 3	Lower 1/2	784	724		754
S96T003924		Upper 1/2	357	408		382.5
S96T003927	158: 4	Lower 1/2	659	684		671.5
S96T004017	158:2A	Lower 1/2	713	633	1,070	805
S96T003760	158:2B	Lower 1/2	400	374	379	384
S96T003759		Upper 1/2	472	562		517
S96T003926	158:3A	Lower 1/2	532	461		496.5
S96T003800	160: 1	Lower 1/2	396	334		365
S96T003801	160: 2	Lower 1/2	256	241		248.5
S96T003839	160:2A	Lower 1/2	192	239		215.5[QC:e]
S96T004036	160:2B	Lower 1/2	343	978	975	765[QC:e]
S96T004035		Upper 1/2	352	324		338

Table B2-55. Tank 241-S-109 Analytical Results: Bulk Density.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			g/mL	g/mL	g/mL
S96T003917	158: 1	Lower ½	1.34	n/a	1.34
S96T003916		Upper 1/2	1.73	n/a	1.73
S96T003733	158: 2	Lower 1/2	1.23	n/a	1.23
S96T003919	158: 3	Lower 1/2	1.59	n/a	1.59
S96T003918		Upper 1/2	1.28	n/a	1.28
S96T003921	158: 4	Lower 1/2	1.27	n/a	1.27
S96T003757	158:2B	Upper 1/2	1.37	n/a	1.37
S96T003920	158:3A	Lower 1/2	1.34	n/a	1.34
S96T003769	160: 1	Lower 1/2	1.27	n/a	1.27
S96T003770	160: 2	Lower 1/2	1.22	n/a	1.22
S96T004028	160:2B	Upper 1/2	1.19	n/a	1.19

Table B2-56. Tank 241-S-109 Analytical Results: Exotherm (DSC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			J/g	J/g	J/g
S96T003927	158: 4	Lower 1/2	0	30.5	15.8
S96T004017	158:2A	Lower 1/2	31.7	47.8	39.75
S96T003760	158:2B	Lower 1/2	0.8	1.1	0.95
S96T003926	158:3A	Lower 1/2	1.2	0	0.6
S96T004036	160:2B	Lower 1/2	9.5	8.9	9.2

Table B2-57. Tank 241-S-109 Analytical Results: Percent Water (TGA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			%	%	%
S96T003923	158: 1	Lower 1/2	7.19	7.21	7.2
S96T003922		Upper 1/2	18.9	27.27	23.085
S96T003734	158: 2	Lower 1/2	7.09	5.26	6.175
S96T003925	158: 3	Lower 1/2	12.79	10.74	11.765
S96T003924		Upper 1/2	7.15	6.69	6.92
S96T003759	158:2B	Upper 1/2	11.03	10.44	10.735
S96T003927	158: 4	Lower 1/2	6	6.1	6.05
S96T004017	158:2A	Lower 1/2	7.79	7.41	7.6
S96T003760	158:2B	Lower 1/2	10.5	12.08	11.29
S96T003759	158:2B	Upper 1/2	11.03	10.44	10.735
S96T003926	158:3A	Lower 1/2	9.2	8.7	8.95
S96T003800	160: 1	Lower 1/2	4.31	0.94	2.625
S96T003801	160: 2	Lower 1/2	1	1.56	1.28
S96T003839	160:2A	Lower 1/2	6.87	8.86	7.865
S96T004036	160:2B	Lower 1/2	20.04	18.57	19.305
S96T004035		Upper 1/2	5.95	6.1	6.025
Liquids			%	%	%
S96T004033	160:2C	DL	52.07	52.78	52.425

Table B2-58. Tank 241-S-109 Analytical Results: Specific Gravity (SpG).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			unitless	unitless	unitless
S96T004033	160:2C	DL	1.375	1.36	1.37

Table B2-59. Tank 241-S-109 Analytical Results: Total Alpha (Alpha Rad).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T004033	160:2C	DL	0.00344	4.140E-04	0.001927[QC:f]

Table B2-60. Tank 241-S-109 Analytical Results: Total Alpha (Alpha).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	0.0224	0.0203	0.02135[QC:b]
S96T003935		Upper 1/2	0.0103	0.00648	0.00839[QC:b,e]
S96T003737	158: 2	Lower 1/2	0.00725	0.00722	0.007235[QC:c]
S96T003938	158: 3	Lower 1/2	0.00611	0.00836	0.007235[QC:e]
S96T003937		Upper 1/2	0.00556	< 0.00502	< 0.00529
S96T003940	158: 4	Lower 1/2	0.00999	0.0084	0.009195[QC:f]
S96T004018	158:2A	Lower 1/2	0.00874	0.00441	0.006575[QC:b,e]
S96T003764	158:2B	Lower 1/2	< 0.00309	0.00295	< 0.00302[QC:c]
S96T003763		Upper 1/2	0.00263	0.00557	0.0041[QC:b,e]
S96T003939	158:3A	Lower 1/2	0.00303	0.00855	0.00579[QC:e]
S96T003815	160: 1	Lower 1/2	0.00329	0.00418	0.003735[QC:e]
S96T003814	160: 2	Lower 1/2	0.00226	0.00237	0.002315[QC:c]
S96T003840	160:2A	Lower 1/2	0.00445	< 0.00461	< 0.00453
S96T004038	160:2B	Lower 1/2	0.0191	0.0132	0.01615[QC:e]
S96T004037		Upper 1/2	0.00543	0.0065	0.005965[QC:c]

Table B2-61. Tank 241-S-109 Analytical Results: Total Beta (Beta).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003737	158: 2	Lower 1/2	27.2	29.5	28.35
S96T003814	160: 2	Lower 1/2	7.31	7.35	7.33

Table B2-62. Tank 241-S-109 Analytical Results: Americium-241 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	< 0.05214	< 0.0496	< 0.05087
S96T003935		Upper 1/2	< 0.1062	< 0.104	< 0.1051
S96T003737	158: 2	Lower 1/2	< 0.04942	< 0.0506	< 0.05001
S96T003938	158: 3	Lower 1/2	< 0.1457	< 0.159	< 0.15235
S96T003937		Upper 1/2	< 0.1075	< 0.102	< 0.10475
S96T003940	158: 4	Lower 1/2	< 0.03247	< 0.0357	< 0.034085
S96T004018	158:2A	Lower 1/2	< 0.03942	< 0.0377	< 0.03856
S96T003764	158:2B	Lower 1/2	< 0.1318	< 0.132	< 0.1319
S96T003763		Upper 1/2	< 0.0356	< 0.0353	< 0.03545
S96T003939	158:3A	Lower 1/2	< 0.115	< 0.126	< 0.1205
S96T003815	160: 1	Lower 1/2	< 0.2043	< 0.193	< 0.19865
S96T003814	160: 2	Lower 1/2	< 0.135	< 0.137	< 0.136
S96T003840	160:2A	Lower 1/2	< 0.16	< 0.166	< 0.163
S96T004038	160:2B	Lower 1/2	< 0.04722	< 0.0471	< 0.04716
S96T004037		Upper 1/2	< 0.0351	< 0.0365	< 0.0358

Table B2-63. Tank 241-S-109 Analytical Results: Cesium-137 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	21.52	18.7	20.11
S96T003935		Upper 1/2	35.41	35.3	35.355
S96T003737	158: 2	Lower 1/2	17.46	18.4	17.93
S96T003938	158: 3	Lower 1/2	3.719	3.53	3.6245
S96T003937		Upper 1/2	0.815	0.764	0.7895
S96T003940	158: 4	Lower 1/2	0.3411	0.37	0.35555
S96T004018	158:2A	Lower 1/2	6.149	6.23	6.1895
S96T003764	158:2B	Lower 1/2	2.37	2.43	2.4
S96T003763		Upper 1/2	1.442	1.4	1.421
S96T003939	158:3A	Lower 1/2	1.302	1.34	1.321
S96T003815	160: 1	Lower 1/2	8.031	8	8.0155
S96T003814	160: 2	Lower 1/2	3.161	3.2	3.1805
S96T003840	160:2A	Lower 1/2	4.302	4.24	4.271
S96T004038	160:2B	Lower 1/2	6.099	5.92	6.0095
S96T004037		Upper 1/2	2.764	2.76	2.762

Table B2-64. Tank 241-S-109 Analytical Results: Cobalt-60 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	< 0.02593	< 0.0229	< 0.024415
S96T003935		Upper 1/2	< 0.037	< 0.0488	< 0.0429[QC:e]
S96T003737	158: 2	Lower 1/2	< 0.02234	< 0.0218	< 0.02207
S96T003938	158: 3	Lower 1/2	< 0.01381	< 0.0167	< 0.015255
S96T003937		Upper 1/2	< 0.01604	< 0.00938	< 0.01271[QC:e]
S96T003940	158: 4	Lower 1/2	< 0.02047	< 0.0246	< 0.022535
S96T004018	158:2A	Lower 1/2	< 0.02421	< 0.0237	< 0.023955
S96T003764	158:2B	Lower 1/2	< 0.01111	< 0.00855	< 0.00983[QC:e]
S96T003763		Upper 1/2	< 0.02282	< 0.028	< 0.02541
S96T003939	158:3A	Lower 1/2	< 0.01609	< 0.014	< 0.015045
S96T003815	160: 1	Lower 1/2	< 0.01518	< 0.0161	< 0.01564
S96T003814	160: 2	Lower 1/2	< 0.01591	< 0.0198	< 0.017855[QC:e]
S96T003840	160:2A	Lower 1/2	< 0.01415	< 0.0167	< 0.015425
S96T004038	160:2B	Lower 1/2	< 0.02067	< 0.0238	< 0.022235
S96T004037		Upper 1/2	< 0.023	< 0.0207	< 0.02185

Table B2-65. Tank 241-S-109 Analytical Results: Europium-154 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	< 0.08371	< 0.0784	< 0.081055
S96T003935		Upper 1/2	< 0.1775	< 0.163	< 0.17025
S96T003737	158: 2	Lower 1/2	< 0.08183	< 0.0708	< 0.076315
S96T003938	158: 3	Lower 1/2	< 0.05066	< 0.0544	< 0.05253
S96T003937		Upper 1/2	< 0.0452	< 0.0424	< 0.0438
S96T003940	158: 4	Lower 1/2	< 0.07135	< 0.0739	< 0.072625
S96T004018	158:2A	Lower 1/2	< 0.08279	< 0.0758	< 0.079295
S96T003764	158:2B	Lower 1/2	< 0.03422	< 0.0485	<0.04136[QC:e]
S96T003763		Upper 1/2	< 0.08122	< 0.0709	< 0.07606
S96T003939	158:3A	Lower 1/2	< 0.04416	< 0.0525	< 0.04833
S96T003815	160: 1	Lower 1/2	< 0.05751	< 0.0588	< 0.058155
S96T003814	160: 2	Lower 1/2	< 0.05021	< 0.0456	< 0.047905
S96T003840	160:2A	Lower 1/2	< 0.04651	< 0.0442	< 0.045355
S96T004038	160:2B	Lower 1/2	< 0.094	< 0.0942	< 0.0941
S96T004037		Upper 1/2	< 0.06741	< 0.0701	< 0.068755

Table B2-66. Tank 241-S-109 Analytical Results: Europium-155 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003936	158: 1	Lower 1/2	< 0.09824	< 0.0933	< 0.09577
S96T003935		Upper 1/2	< 0.1883	< 0.19	< 0.18915
S96T003737	158: 2	Lower 1/2	< 0.09239	< 0.0943	< 0.093345
S96T003938	158: 3	Lower 1/2	< 0.06363	< 0.0644	< 0.064015
S96T003937		Upper 1/2	< 0.04461	< 0.0465	< 0.045555
S96T003940	158: 4	Lower 1/2	< 0.06164	< 0.0668	< 0.06422
S96T004018	158:2A	Lower 1/2	< 0.07339	< 0.0722	< 0.072795
S96T003764	158:2B	Lower 1/2	< 0.05258	< 0.0511	< 0.05184
S96T003763		Upper 1/2	< 0.06695	< 0.0695	< 0.068225
S96T003939	158:3A	Lower 1/2	< 0.04557	< 0.0483	< 0.046935
S96T003815	160: 1	Lower 1/2	< 0.09965	< 0.099	< 0.099325
S96T003814	160: 2	Lower 1/2	< 0.06701	< 0.0656	< 0.066305
S96T003840	160:2A	Lower 1/2	< 0.07922	< 0.0767	< 0.07796
S96T004038	160:2B	Lower 1/2	< 0.08095	< 0.0802	< 0.080575
S96T004037		Upper 1/2	< 0.06675	< 0.0667	< 0.066725

Table B2-67. Tank 241-S-109 Analytical Results: Strontium-89/90 (Sr).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003737	158: 2	Lower 1/2	7.81	8.55	8.18
S96T003814	160: 2	Lower 1/2	2.56	2.31	2.435

Table B2-68. Tank 241-S-109 Analytical Results: Total Inorganic Carbon (TIC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			µg/g	µg/g	µg/g
S96T003923	158: 1	Lower 1/2	8,490	6,640	7,565[QC:e]
S96T003922		Upper 1/2	23,500	25,000	24,250
S96T003734	158: 2	Lower 1/2	7,560	7,380	7,470
S96T003925	158: 3	Lower 1/2	4,980	4,290	4,635
S96T003924		Upper 1/2	1,220	1,470	1,345
S96T003927	158: 4	Lower 1/2	303	310	306.5
S96T004017	158:2A	Lower 1/2	3,250	3,290	3,270[QC:d]
S96T003760	158:2B	Lower 1/2	2,200	1,980	2,090
S96T003759		Upper 1/2	1,510	1,480	1,495
S96T003926	158:3A	Lower 1/2	1,770	1,820	1,795
S96T003800	160: 1	Lower 1/2	4,390	5,180	4,785
S96T003801	160: 2	Lower 1/2	1,970	1,690	1,830
S96T003839	160:2A	Lower 1/2	1,180	1,190	1,185
S96T004036	160:2B	Lower 1/2	848	3,760	2,304[QC:e]
S96T004035		Upper 1/2	1,820	1,980	1,900

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

This chapter covers the overall quality and consistency of the current sampling results for tank 241-S-109, and presents the results of the calculation of an analytical-based inventory.

This section also evaluates sampling and analysis factors that may affect how the data are interpreted. These factors are used to assess the overall quality and consistency of the data and identify limitations in its use.

B3.1 FIELD OBSERVATIONS

The safety screening DQO requirement (Dukelow 1995) is that at least two widely spaced risers be sampled if not enough data are available to specify otherwise. This was only partially fulfilled because only a partial core sample could be obtained by the push method. Additional samples are required to more fully characterize this tank. Sample recovery was good for the risers sampled, and HHF intrusions were negligible.

B3.2 QUALITY CONTROL ASSESSMENT

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses and blanks that are performed in conjunction with the chemical analyses. Each of these quality control tests was conducted on the July 1996 core samples, allowing a full assessment regarding the accuracy and precision of the data. Additional detail is provided in Fritts (1996). The SAP (Field 1996) establishes specific accuracy and precision criteria for the four quality control checks. Samples with one or more quality control results outside of the criteria are identified by footnotes in the data summary tables.

The precision is estimated by the relative percent difference [RPD], defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times 100. The degree of variability in this waste does not necessarily reflect on the laboratory procedures or equipment, but may be intrinsic to the sample. The variability may result from the very small samples (10 to 20 mg) used in this analysis. At such small sizes, the samples need a high degree of homogeneity to achieve reproducible results. The requisite degree of homogeneity may not have been achievable with the procedures and equipment in place at the time of analysis. Difficulties in producing a highly homogeneous subsample are probably responsible for most of the RPD values exceeding 20 percent.

Preparation blanks are used to identify any sample contamination that was introduced in the laboratory during sample breakdown, digestion, and dilution. The blank results indicated that contamination was not a problem.

Quality control results are identified in Appendix B.2 tables. Although some samples did have quality control results outside the SAP boundaries, the vast majority of the quality control results were within the boundaries specified in the SAP (Field 1996). No impact to the validity or use of the data was found.

B3.3 DATA CONSISTENCY CHECKS

Comparing different analytical methods helps in assessing data consistency and quality. Data consistency checks included comparing phosphorus and sulfur as analyzed by ICP with phosphate and sulfate as analyzed by IC, and calculating a mass and charge balance to assess data consistency.

B3.3.1 Comparison of Results from Different Analytical Methods

The following data consistency checks compare the results from IC and ICP analytical methods for sulphate and phosphate. A close correlation between the two methods strengthens the credibility of both results. All segment analytical mean results were taken from Table B3-5.

The analytical phosphorus mean result in the saltcake as determined by ICP:A, was 4,028 μg/g, which converts to 12,325 μg/g of phosphate (assuming that all the phosphorous is present as phosphate). This compares relatively well with the IC phosphate mean result of 12,720 μg/g. The ratio of IC to ICP results indicates the phosphate was 100- percent soluble. The RPD between these two phosphate estimates was a reasonable 3 percent (see Table B3-1).

The ICP sulfur value 2,611 μg/g converts to 7,833 μg/g of sulfate (assuming all the sulfur is present as sulfate). This compares favorably with the IC sulfate result of 8,208 μg/g. The RPD between the two sulfate estimates was 4.5 percent, meaning that almost all of the sulfur/sulfate in the saltcake was soluble. In this case, the ion chromatography results were considered the authoritative result, and sulfate solubility was considered 100 percent.

Table B3-1. Comparison of Phosphate/Phosphorous and Sulfate/Sulfur Concentrations by Different Methods.

Saltcake		
ICP:A	IC	
PO_4^{3-} (μg/g)	PO_4^{3-} (μg/g)	Solubility (IC/ICP)
12,325	12,720	97%
SO_4^{2-} (μg/g)	SO_4^{2-}(μg/g)	Solubility (IC/ICP)
7,833	8,208	95%

Notes:

ICP:A = Inductively coupled plasma - acid prepared sample result, converted to the assumed anion form.

IC = Ion chromatography result

B3.3.2 Mass and Charge Balance

The principle objective in performing a mass and charge balance was to determine whether the measurements were consistent. In calculating the balances, only analytes that were detected at a concentration of 1,000 μg/g or greater were considered (see Table B3-2).

Except for sodium, the cations listed in Table B3-2 were assumed to be either in their most common oxide/hydroxide form or an insoluble phosphate. The concentrations of the assumed species were calculated stoichiometrically. Because precipitates are neutral species, all positive charge was attributed to sodium. Acetate species were assumed for the total organic carbon analysis. The other anionic analytes listed in Table B3-3 were assumed to be present as mostly sodium salts and were expected to balance the positive charge exhibited by the cations. Sulfur, present as the sulfate ion, was assumed to be completely water soluble, and appeared only in the anion mass and charge calculations. The water soluble phosphate was included in the anion mass and charge data and was subtracted from the total phosphate calculated from the ICP. The concentrations of the cationic species, the anionic species, and the percent water were ultimately used to calculate the mass balance. The uncertainty estimates (RSDs) associated with each analyte, and the uncertainty for the cation and anion totals also are shown in the tables.

The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from $\mu g/g$ to weight percent.

$$\text{Mass balance} = \%\ \text{water} + 0.0001 \times \{\text{total analyte concentration}\}$$
$$= \%\ \text{water} + 0.0001 \times \{Al(OH)_3 + Na^+ + Cr(OH)_3 + C_2H_3O_2^- + NO_3^- + NO_2^- + CO_3^{-2} + PO_4^{-3} + SO_4^{-2}\}$$

The total analyte concentrations calculated from the previous equation was 898,260 $\mu g/g$ or 89.8 percent. The mean weight percent water obtained from thermogravimetric analysis was 7.3 percent. The mean water content is only slightly lower (6.6 percent) accounting for HHF contamination. The mass balance resulting from adding the percent water to the total analyte concentration is 97.1 percent (Table B3-4) or 96.4 accounting for HHF contamination.

Table B3-2. Cation Mass and Charge Data.

Analyte	Concentration ($\mu g/g$)	Assumed Species	Concentration of Assumed Species ($\mu g/g$)	Charge ($\mu eq/g$)
Aluminum	1,730	$Al(OH)_3$	5,010	0.00
Chromium	1,560	$Cr(OH)_3$	3,090	0.00
Sodium	235,700	Na^+	235,700	10,250
Total			243,800	10,250

Table B3-3. Anion Mass and Charge Data.

Analyte	Concentration ($\mu g/g$)	Charge ($\mu eq/g$)
Acetate (TOC)	1,530	-26
Nitrate	602,600	-9,720
Nitrite	4,670	-102
Carbonate (TIC)	24,730	-824
Phosphate	12,720	-398
Sulfate	8,210	-171
TOTALS	654,460	-11,241

Table B3-4. Mass Balance Totals.

	Concentrations (μg/g)	Charge (μeq/g)
Total from Table B3-2 (cations)	243,800	10,250
Total from Table B3-3 (anions)	654,460	-11,241
Water %	7.3%	0.00
Total	971,260	-991

The following equations demonstrate the derivation of total cations and total anions; the charge balance is the ratio of these two values.

Total cations (microequivalents) = $Na^+/23.0$ = 10,250 microequivalents

Total anions (microequivalents) = $C_2H_3O_2^-/59.0 + NO_3^-/62.0 + NO_2^-/46.0 + CO_3^{-2}/60.0 + PO_4^{-3}/31.7 + SO_4^{-2}/48.1$ = -11,241 microequivalents

The charge balance was 91.2 percent. It was obtained by dividing the sum of the positive charge by the sum of the negative charge and taking the absolute value. Perfect agreement is 1,000,000 μg/g for the mass balance and 1.00 for the charge balance with no net charge remaining.

In summary, these calculations yield a reasonable mass balance and charge balance (97.1 percent for mass balance and 91.2 percent for charge balance), indicating that the mean analytical results for the tank were a complete description of the top portion of the tank.

B3.4 CALCULATION OF ANALYTICAL BASED MEANS AND INVENTORY

The statistics in this section were calculated using analytical data from the most recent sampling event of tank 241-S-109. Analysis of variance (ANOVA) techniques were used to estimate the mean and calculate confidence limits on the mean for each analyte that did not have a majority of results below the detection limit. The statistics in this section are used to calculate a sampling inventory (Appendix D).

The following are ANOVA estimates based on the data from cores 158 and 160 from tank S-109. For analytes with at least 50 percent detected values, an estimate of the mean concentration and the confidence interval on the mean concentration were calculated. In cases where some, but not most, of the analytical results were less than the detection limit, the detection limit values were used in the calculations. The average concentration estimates, along with lower and upper limits to a two-sided 95-percent confidence interval, are given in Table B3-5. In this table, $\hat{\mu}$ and SD($\hat{\mu}$) (SD = standard deviation of the mean) are the restricted maximum likelihood estimate of the mean and standard deviation of the mean (Harville 1977). The lower and upper limits to the 95 percent confidence interval on the mean are LL and UL. Some analytes had a lower confidence limit—less than zero. Because an actual inventory value of less than zero is not possible, the lower limit is reported as zero, whenever this occurred.

Table B3-5. Confidence Interval Limits on Analytical Mean Analyte Concentrations in Saltcake. (2 sheets)

Analyte	Method	Mean Concentration		Units	95% Confidence Interval	
		$\hat{\mu}$	SD($\hat{\mu}$)		LL	UL
Aluminum	ICP:A	1.734e+03	6.01e+02	μg/g	0	9360.0
Aluminum	ICP:W	1.129e+03	9.45e+02	μg/g	0	13100.00
Boron[1]	ICP:A	5.151e+01	7.58e+00	μg/g	0	148
Boron	ICP:W	5.095e+02	1.75e+01	μg/g	286.75	732.25
Bulk density	Bulk Density	1.325e+00	8.22e-02	g/mL	0.28	2.37
Calcium[1]	ICP:A	1.006e+02	1.61e+01	μg/g	0	304.78
Cesium-137	GEA:F	7.967e+00	4.26e+00	μCi/g	0	62.07
Chloride[1]	IC:W	3.853e+02	1.09e+02	μg/g		1765.83
Chromium	ICP:A	1.560e+03	4.19e+02	μg/g	0	6883.97
Chromium	ICP:W	9.383e+02	3.37e+02	μg/g	0	5218.10
Exotherm - transition 1	DSC	1.644e+01	6.31e+00	J/g	0	96.64
Gross alpha	Alpha Rad	1.927e-03	3.32e-03	μCi/mL	0	0.04
Gross alpha[1]	Alpha:F	7.684e-03	1.68e-03	μCi/g	0	0.03
Iron[1]	ICP:A	1.311e+03	1.28e+03	μg/g	0	17610.27
Lithium[1]	ICP:A	2.583e+02	1.17e+02	μg/g	0	1742.29
Manganese	ICP:A	2.243e+01	9.63e+00	μg/g	0	144.73
Nitrate	IC:W	6.026e+05	4.30e+04	μg/g	5570	1.15e+6
Nitrite[1]	IC:W	4.673e+03	6.72e+02	μg/g	0	13214.49
Oxalate[1]	IC:W	2.732e+03	6.00e+02	μg/g	0	10360.81
Phosphate[1]	IC:W	1.272e+04	3.84e+03	μg/g	0	61477.11
Phosphorus	ICP:A	4.028e+03	1.08e+03	μg/g	0	17808.51
Phosphorus	ICP:W	3.855e+03	1.99e+03	μg/g	0	29129.79

Table B3-5. Confidence Interval Limits on Analytical Mean Analyte Concentrations in Saltcake. (2 sheets)

Analyte	Method	Mean Concentration		Units	95% Confidence Interval	
		$\hat{\mu}$	SD($\hat{\mu}$)		LL	UL
Silicon	ICP:A	4.018e+02	1.89e+02	μg/g	0	2809.39
Silicon	ICP:W	3.233e+02	4.45e+01	μg/g	0	889.20
Silver	ICP:A	1.633e+01	3.60e-01	μg/g	11.75	20.90
Silver	ICP:W	1.773e+01	3.41e-01	μg/g	13.40	22.07
Sodium	ICP:A	2.357e+05	3.10e+03	μg/g	1.96e+06	2.75e+05
Sodium	ICP:W	2.551e+05	5.21e+03	μg/g	1.89e+05	3.21e+05
Strontium-89/90	Sr:F	5.308e+00	2.87e+00	μCi/g	0	41.81
Sulfate	IC:W	8.208e+03	3.64e+03	μg/g	0	54449.54
Sulfur	ICP:A	2.567e+03	1.32e+03	μg/g	0	19286.67
Sulfur	ICP:W	2.611e+03	1.87e+03	μg/g	0	26407.84
Total Inorganic	TIC	4.939e+03	2.50e+03	μg/g	0	36653.79
Total organic carbon[1]	TOC	6.210e+02	1.78e+02	μg/g	0	2877.15
Uranium	U:F	5.823e+01	3.72e+01	μg/g	0	531.21
Zinc	ICP:A	1.966e+01	8.64e-01	μg/g	8.68	30.64
Zinc	ICP:W	1.188e+01	4.78e-01	μg/g	5.80	17.96

Note:

Calculations contain up to 50 percent non-detect estimates of the analyte concentration.

The model used to produce the results is

$$Y_{ijk} = \mu + C_i + S_{ij} + E_{ijk} \tag{4}$$

where

Y_{ijk} = The measured value of concentration of a constituent in replicate *j* of core *i*

μ = The mean concentration of the constituent in the tank

C_i = The deviation of concentration in core *i* from the mean value

S_{ij} = The deviation of concentration in segments from the mean value.

E_{ijk} = The analytical (lab) error in the measurements.

The 95-percent confidence upper limit (UL) and lower limit (LL) on the mean were calculated using

$$\hat{\mu} \pm t_{(a-1,0.025)} * \sqrt{\hat{\sigma}^2_{\hat{\mu}}}.$$

Where $\hat{\mu}$ is the estimated mean, *a* is the number of core samples, $\hat{\sigma}^2_{\hat{\mu}}$ is the variance of the sample mean and $t_{(a-1,0.025)}$ is the quantile from Student's t distribution with *a-1* degrees of freedom for a two-sided 95 percent confidence interval.

For the data from tank 241-S-109, *a* is 2 and $t_{(1,\ 0.025)}$ is 12.706. The mean, $\hat{\mu}$, and variance, $\hat{\sigma}^2_{\hat{\mu}}$, were estimated using restricted maximum likelihood estimation (REML) methods.

B4.0 APPENDIX B REFERENCES

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

Appendix C shows the analyses required for the applicable data quality objective (DQO) reports for tank 241-S-109. Specifically, this appendix shows and documents the statistical and other numerical manipulations required in the DQO reports. The two analyses required for tank 241-S-109 are documented in Sections C1 and C2.

- **Section C1**. Statistical analysis supporting the Safety Screening DQO (Dukelow et al. 1995).
- **Section C2**. Gateway analysis supporting the *Historical Model Evaluation Data Requirements* DQO (Simpson and McCain 1996).
- **Section C3**. Analysis for hydrostatic head fluid contamination.
- **Section C4**. Comparison with historical analyses.
- **Section C5**. References for Appendix C.

C1.0 STATISTICS FOR SAFETY SCREENING DQO

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals on the mean for each subsample. In this appendix, one-sided confidence limits for supporting the safety screening DQO are calculated for total alpha and DSC analyses for tank 241-S-109. All data considered in this section are taken from the final laboratory data package for the 1996 push core sampling event for tank 241-S-109 (Fritts 1996).

Confidence intervals were computed for each sample number. The upper limit (UL) of a one-sided 95 percent confidence interval for the mean is

$$\hat{\mu} + t_{(n-1,0.05)} * \sqrt{\frac{\hat{\sigma}^2}{n}}.$$

where $\hat{\mu}$ is the mean of the data, n is the number of observations, $\hat{\sigma}^2$ is the estimate of the variance, and $t_{(n-1,0.95)}$ is a quantile from Student's t distribution with $n-1$ degrees of freedom for a one-sided 95-percent confidence level. For the samples analyzed, n is 2 and $t_{(1,0.05)}$ is 6.314 for each sample.

The upper limit of the 95-percent confidence interval for each sample number based on the total alpha data is listed in Table C1-1. Each confidence interval can be used to make the following statement. If the upper limit is less than 40 μCi/g, then one would reject the null hypothesis that the total alpha is greater than or equal to 40 μCi/g at the 0.05 level of significance. The upper limit of 40 μCi/g was calculated from the 1 g/L plutonium limit assuming a density of 1.55 g/mL (Agnew et al. 1996) and assuming that all the plutonium is ^{239}Pu. For the 241-S-109 samples, all upper limits for total alpha were well below the safety screening criteria.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Total Alpha for Tank 241-S-109.

Sample number	Sample Location	Sample Portion	$\hat{\mu}$ (μCi/g)	UL (μCi/g)
96T003737	158: 2	Lower ½	7.24E-03	7.33E-03
96T003763	158: 2B	Upper ½	4.10E-03	1.34E-02
96T003764	158: 2B	Lower ½	2.32E-03[1]	2.46E-03
96T003814	160: 2	Lower ½	2.32E-03	2.66E-03
96T003815	160: 1	Lower ½	3.74E-03	5.64E-03
96T003840	160: 2A	Lower ½	4.53E-03[1]	5.04E-03
96T003935	158: 1	Upper ½	8.39E-03	2.05E-02
96T003936	158: 1	Lower ½	2.14E-02	2.80E-02
96T003937	158: 3	Upper ½	5.29E-03[1]	6.99E-03
96T003938	158: 3	Lower ½	7.24E-03	1.43E-03
96T003939	158: 3A	Lower ½	5.79E-03	2.32E-02
96T003940	158: 4	Lower ½	9.20E-03	1.42E-02
96T004018	158: 2A	Lower ½	6.58E-03	2.02E-02
96T004033	160: 2C	Drainable Liquid	1.93E-03	1.15E-02
96T004037	160: 2B	Upper ½	5.97E-03	9.34E-03
96T004038	160: 2B	Lower ½	1.62E-02	3.48E-02

Note:

[1]Estimate; contains values below detection levels.

Confidence intervals were calculated in the same way for tank 241-S-109 exotherms. The mean and upper limits to a 95-percent confidence interval on the mean are included in Table C1-2. This table shows that all exotherms were well below the safety screening limit of -480 J/g.

Table C1-2. 95-Percent Confidence Interval Upper Limits for Dry Weight Exotherms for Tank 241-S-109.

Sample number	Sample Location	Sample Portion	$\hat{\mu}$ (J/g)	UL (J/g)
96T003760	158: 2B	Lower ½	1.07	2.14
96T003926[1]	158: 3A	Lower ½	0.66	4.82
96T003927[1]	158: 4	Lower ½	16.2	118.7
96T004017	158: 2A	Lower ½	43.0	98.0
96T004036	160: 2B	Lower ½	11.4	13.7

Note:

[1]The UL was calculated using "zero" as the value of the missing primary/duplicate observation.

C2.0 GATEWAY ANALYSIS FOR HISTORICAL MODEL DQO

The *Historical Model Evaluation Data Requirements* (Simpson and McCain 1996) requires that a gateway analysis be performed on the analytical data obtained from tank 241-S-109. The gateway analysis provides a quick screening check of the analytical data before a more thorough set of analyses is performed on the tank samples. If the gateway analysis fails, the remainder of the analyses in the historical DQO will not be performed. Tank S-109 was selected for historical evaluation because it was expected to contain a thick S1-saltcake layer (Agnew et al. 1996). The indicator analytes for S1-saltcake are sodium, aluminum, chromium, percent water, nitrate, carbonate, and sulfate. Segment 2 (lower half) samples were selected for historical gateway analyses comparisons. The historical gateway analysis consists of two parts, which are described in the following paragraphs.

The first part of the gateway analysis is to check whether the sum of the mass of a set group of analytes (indicator analytes) contributes over 85 percent of the total tank waste mass. The second part of the gateway analysis is to check whether analyte concentrations compare with DQO-defined concentrations for selected "fingerprint analytes." This comparison is to determine whether a predicted waste type is in the tank and at the predicted location in the waste matrix. If the analytical results are more than 10 percent of the DQO levels (ratio of 0.1), the waste type and layer identification are considered acceptable (Simpson and McCain 1996).

Averaging analytical results for core 158 segment 2 lower half and 160 segment 2 lower half, sodium and nitrate alone accounted for over 98 percent of the waste mass. All of the fingerprint analytes accounted for 96 percent of the total mass. Therefore, the first part of the analysis passed. Table C2-1 compares analytical results with DQO-defined concentrations for fingerprint analytes. All fingerprint analytes passed the gateway analysis except for aluminum, which was found at a much lower concentration than expected. Consequently, the second part of the analysis failed. The weight percent water was also much lower than expected, but was slightly greater than 10 percent.

Table C2-1. Comparison of Analytical Results with Historical DQO Levels.

Fingerprint Analyte	Mean Analytical Result ($\mu g/g$)	Historical DQO Level		Percent
		Concentration ($\mu g/g$)	10% of DQO ($\mu g/g$)	
Sodium	250,000	195,400	19,500	128
Aluminum	1,160	31,000	3,100	3.7
Chromium	840	3,000	300	28
Nitrate	660,000	274,300	27,430	241
Carbonate (TIC X 5)	23,250	17,000	1,700	137
Sulfate	8,650	13,000	1,300	66.5
Percent water	3.7	32.1	3.2	11.5

Note:

Simpson and McCain (1996)

C3.0 ANALYSIS FOR HYDROSTATIC HEAD FLUID CONTAMINATION

Water was used as a hydrostatic head fluid in the acquisition of cores 158 and 160. Lithium bromide was added to the HHF as a tracer. Analyses for lithium and bromide were performed in accordance with the sampling and analysis plan (Field 1996) to detect contamination of the waste samples with HHF. Analytical data are shown in Appendix D.

C3.1 LITHIUM

Lithium was analyzed by ICP using procedures LA-505-151, Rev. D-2, and LA-505-161, Rev. A-1. Samples were prepared in accordance with procedure LA-505-151. Eight of the tank 241-S-109 solids samples, 1 drainable liquid sample and 3 liner liquid samples had lithium results or detection limits that exceeded the notification limit of 100 μg/g specified in the sampling analysis plan (Field 1996). The analytical results for lithium are presented in Table C3-1. No projected inventory was calculated for lithium because lithium is an artifact of the sampling operations, not a constituent of the waste.

Because of the potential incursion of HHF into these samples, bromide was requested as a secondary analysis.

Table C3-1. Tank 241-S-109 Lithium Samples That Exceeded Notification Limits.

Sample Number	Core:Segment	Average Li (μg/g)
SOLIDS		
S96T004019	158: S2A Lower ½	157
S96T003765	158: S2B Upper ½	249
S96T003766	158: S2B Lower ½	270
S96T003945	158: S3A Lower ½	497
S96T003943	158: S3 Upper ½	477
S96T003944	158: S3 Lower ½	766
S96T004040	160: S2B Upper ½	190
S96T004041	160: S2B Lower ½	355
DRAINABLE LIQUID		
S96T004033	160: S2C	205
LINER LIQUID		
S96T003755	158: S2	1,950
S96T003933	158: S3	2,040
S96T003825	160: S2A	2,180
S96T004026	160: S2B	808

C3.2 BROMIDE

Bromide was analyzed by IC using procedure LA-533-105. Bromide analyses are required when lithium results exceed the notification limit listed in Field (1996). Bromium results where lithium notification levels were exceeded are shown in Table C3-2.

For the bromide concentrations observed, water content caused by HHF intrusion was determined using the approach outlined in (Winkelman 1996). As can be seen by the results in Table C3-2, all of the samples for which lithium exceeded 100 μg/g were contaminated by the HHF used during the push mode core sampling process. This was expected because HHF was added to soften the waste. The drainable liquid sample from core 160, segment 4 is mostly HHF. Because the HHF added water to these samples, corrections to the TGA results were made for bromide results, and are reported in Table C3-3. Lithium may precipitate out of solution, giving a biased low result. The Winkelman (1996) model is less accurate with very low water contents such as were observed in tank 241-S-109, and some corrections may be biased low. Negative values from the model were assumed to be zero. Nearly all of the liner liquid was determined to be HHF.

Table C3-2. Tank 241-S-109 Bromium Results for Samples that Exceeded Lithium Limits.

Sample Number	Core:Segment	Average Br (μg/g)
SOLIDS		
S96T004020	158: S2A Lower ½	2,850
S96T003767	158: S2B Upper ½	2,120
S96T003768	158: S2B Lower ½	2,790
S96T003951	158: S3A Lower ½	1,460
S96T003949	158: S3 Upper ½	<2,620
S96T003950	158: S3 Lower ½	1,435
S96T004042	158: S2B Upper ½	<1,025
S96T004043	158: S2B Lower ½	2,090
DRAINABLE LIQUID		
S96T004033	160: S2C	3,540
LINER LIQUID		
S96T003755	158: S2	19,900
S96T003933	158: S3	22,700
S96T003825	160: S2A	20,300
S96T004026	160: S2B	<12.7

Table C3-3. Correction to TGA Results Caused by HHF Contamination.

Sample Number	Core/Segment	TGA Result (%)	Corrected TGA Result (%) (based on Br)
SOLIDS			
S96T004017	158: S2A Lower ½	7.6	0
S96T003759	158: S2B Upper ½	10.7	2.2
S96T003760	158: S2B Lower ½	11.3	0
S96T003926	158: S3A Lower ½	9.0	4.3
S96T003924	158: S3 Upper ½	6.9	0
S96T003925	158: S3 Lower ½	11.8	6.2
S96T004035	158: S2B Upper ½	6.0	1.9
S96T004036	158: S2B Lower ½	19.3	11.7
DRAINABLE LIQUID			
S96T004033	160: S2C	52.1	44.5

C4.0 COMPARISON WITH HISTORICAL ANALYSES

Most of the historical sample analyses were of supernate or liquids in the tank. These were not compared with the June/July 1996 sample event because the tank now contains no supernate and appears to contain very little drainable liquid.

Although it is not known where in the tank the 1976 sample was taken from, the description of the sample (see Section B2.4) indicates that the sample was saltcake. The 1996 and 1976 sample results are compared in Table C4-1. Sodium, nitrate, chromium, silicon, and sulfate results were all within 50 percent for the two sample results. The biggest difference in the two data sets is that the 1976 data set shows higher values for aluminum and total inorganic carbon and a low value for phosphate.

Table C4-1. Comparison of 1996 and 1976 241-S-109 Sample Data.

Chemical Analysis		
Component	1996 ($\mu g/g$)	1976 ($\mu g/g$)
Al	1,734	13,000
Ca	101	800
Cr	1,560	1,000
Fe	1,311	3,000
Mn	22.4	30
Na	235,700	350,000
Si	402	1,000
OH	-	3,000
NO_2	4,670	14,000
NO_3	602,600	535,000
PO_4	12,700	100
SO_4	8,210	9,000
TIC	4,940	42,000
TOC	621	-
Radiological Analysis		
^{137}Cs	7.97 $\mu Ci/g$	71.8 $\mu Ci/g$
$^{89/90}Sr$	5.31 $\mu Ci/g$	14.6 $\mu Ci/g$

C5.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-S-109

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-S-109

D1.0 BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-S-109

The following evaluation provides a best-basis inventory estimate for chemical and radionuclide components in tank 241-S-109.

D1.1 EXPECTED TYPE OF WASTE BASED ON THIS ASSESSMENT

Agnew et al. (1996b)	SMMS1, CWR1
Hill et al. (1995)	B, R

It is not known whether the sludge layer in the tank is R cladding waste (CWR1) or R waste. Based on tank transfer history (Agnew et al. 1996a) and radioactivity estimates determined from tank headspace temperatures (see Appendix E), it is assumed that the small sludge layer is R waste and not CWR1 as reported in Agnew et al. (1996b).

D1.2 TANK INVENTORY ESTIMATES

Two inventories have been developed for Tank 241-S-109. A sampling inventory, based on core sampling results (Fritts 1996) and the HDW inventory (Agnew et al. 1996b). The sampling and HDW inventories can not be compared directly, because they are calculated differently. The sample inventory was based on partial core samples taken from two risers. None of the sludge expected at the bottom of the tank was recovered during this sampling event. Consequently, the sample inventory is only for the saltcake portion of the tank or 1,870 kL (494 kgal) and is calculated based on a mean sample density of 1.3 g/mL. Further, the sample inventory in Table D1-1 assumes that the small portion of saltcake recovered is representative of the entire saltcake volume. This is not necessarily true, as discussed in section D3.0. The HDW inventory (Agnew et al. 1996b) includes both the saltcake and sludge volumes for a total volume of 1,920 kL (507 kgal). The HDW inventory is calculated using an estimated average density of 1.5 g/mL for the tank.

The sampling and HDW inventories (Tables D1-1 and D1-2) provide a starting point for calculating a best-basis inventory for the tank that combines the best information from the sampling data, modeling estimates, and process information.

Table D1-1. Sampling-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-S-109. (2 sheets)

Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)
Al	4215	97,000	Ni	NR	667
Ag	43.1	NR	NO_2	11,360	2.29E+5
As	NR	NR	NO_3	1.46E+6	5.55E+5
Ba	NR	NR	OH	NR	2.56E+5
Be	NR	NR	oxalate	NR	2.17E-3
Bi	NR	288	Pb	NR	1480
Ca	245	2570	Pd	NR	NR
Ce	NR	NR	P as PO_4	30900	11,300
Cd	NR	NR	Pt	NR	NR
Cl	937	11,900	Rh	NR	NR
Co	NR	NR	Ru	NR	NR
Cr	3,790	NR	Sb	NR	NR
Cr^{+3}	NR	6810	Se	NR	NR
Cr^{+6}	NR	NR	Si	977	3700 (as SiO_3)
Cs	NR	NR	S as SO_4	19,950	33,000
Cu	NR	NR	Sr	NR	8.41E-4
F	NR	1450	Te	NR	NR
Fe	3,190	1170	TIC	12,000	32600
FeCN/CN	NR	NR	Th	NR	NR
formate	NR	NR	Tl	NR	NR
Hg	NR	42.6	TOC	1,510	0.358 (wt% C)
K	NR	3350	U_{total}	142	7440
La	NR	4.0E-3	V	NR	NR
Mg	NR	NR	W	NR	NR

Table D1-1. Sampling-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-S-109. (2 sheets)

Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)
Mn	54.4	318	Zn	47.8	NR
Mo	NR	NR	Zr	NR	87.2 (as $ZrO(OH)_2$)
Na	6.2E+5	4.67E+5	H_2O (Wt%)	NR	40.1
Nd	NR	NR	density (kg/L)	1.3	1.52
NH_4	NR	1800			

Notes:
[1]Fritts (1996)
[2]Agnew et al. (1996b)

Table D1-2. Sampling and Predicted Inventory Estimates for Radioactive Components in Tank 241-S-109.

Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)	Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)
^{14}C	NR	NR	^{237}Np	NR	NR
^{90}Sr	2.76E+5	2.14E+5	$^{239/240}Pu$	NR	255
^{99}Tc	NR	NR	^{241}Am	NR	NR
^{129}I	NR	NR	Total α	18.7	NR
^{137}Cs	1.06E+5	4.82E+5	Total β	NR	NR
^{154}Eu	NR	NR			

Notes:
[1]Fritts (1996)
[2]Agnew et al. (1996b).

D2.0 INVENTORY EVALUATION

The following evaluation provides an engineering assessment of tank 241-S-109 contents. For this evaluation, the following assumptions and observations are made:

- Tank waste mass is calculated using the measured density of the saltcake (1.3 g/mL) and the tank volume listed by Agnew et al. (1996b), which is 494 kgal of saltcake, and 13 kgal of sludge.

- Only the SMMS1 and R waste streams contributed to solids formation.

- Bulk component information for the sludge layer is sufficient for comparing analytical and predicted data sets. This information can be obtained from technical flowsheets (refer to Table D2-1). Note in this case there is no analytical data so only the technical flowsheet information is available.

- No radiolysis of NO_3 to NO_2 and no additions of NO_2 to the waste for corrosion purposes are factored into this evaluation.

- All Bi and Al precipitate.

- No Si from blowsand is factored into this evaluation.

- All NO_3, Na and SO_4, remain dissolved in the interstitial liquid.

- Interstitial liquid is a composite of all wastes. Contributions of dissolved components are weighted by volume.

- Concentration of components in interstitial liquid is based on a void fraction of 0.686 the average of (R1 and R2) as reported by Agnew et al. (1996b). This factor is higher than the present void fraction but is assumed to better represent the original void fraction.

- Cr and Fe partition between the liquid and solid phases.

Technical flowsheet information for the average R streams is provided in Table D2-1. The comparative LANL defined waste streams also are provided in this table. Note that the REDOX coating waste average flowsheet is also included for comparison purposes.

Table D2-1. Technical Flowsheet and LANL Defined Waste Streams.

Analyte	Flowsheet[1] REDOX (M)	Def Waste R1/R2 (M)	Flowsheet RCW [ave] (M)	Defined Waste RCW (M)
NO_3	4.53	3.3	0.63	0.885
NO_2	0	0	1.3	0.85
SO_4	0.029	0.025	0	0.0125
Bi	0.00003	0	0	0.003
Fe	0.013	0.050	0	0.0152
Si	0	0.029	0.063	0.015
U	0.0075	0.007	0.006	0.019
Al	1.11	0.89	2.13	1.39
Cr	0.178	0.091	0	0.003
PO_4	0	0	0	0
Mn	0.00	0.00	0.00	0.00
Na	6.98	4.14	4.9	2.87
F	0	0	0	0
K	0	0.015	0	0.0028

Note:

[1]This is an average of REDOX Flowsheets #5 through #8, which operated from 1955 until 1965.

D3.0 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION

D3.1 BASIS FOR SALTCAKE CALCULATIONS USED IN THIS ENGINEERING EVALUATION

The sample analyses for saltcake data were assumed to be correct for tank 241-S-109. The total inventory derived by this engineering analysis differs from the analytical data only in one significant way. The analytical, sample-based inventory was developed from only partial core data. The mean concentrations for each analyte were multiplied by the total saltcake solids volume of the tank to obtain the total solids inventory. In the engineering assessment the solids volume represented by sludge was estimated by process flowsheet information and was added to the saltcake inventory. In other similar tanks such as 241-S-101, 241-S-102, and 241-U-102 only Al showed a consistent trend as having twice as high of concentration in the lower half of the saltcake portion when sludge is beneath the saltcake. The other analytes appear to be more uniform through the saltcake. Because only the top portion of the saltcake was analyzed, the analytical mean concentration was multiplied by 1.5 for Al to correct for this trend, as the mean was derived from the top half of the saltcake. The 1.5 comes from the average of 1X for the top measured Al and 2X for the bottom portion of the Al that was not analyzed but assumed to contain twice the concentration of Al.

Several boxes of records were examined to get information about evaporator campaigns for the 242-T and 242-S evaporators. Analytical data for the 242-T campaigns have not been found and only limited analytical data were recovered concerning the 242-S campaigns. Personnel involved with these evaporators suggested that the analytical molarities for saltcakes produced by both of these evaporators may be comparable. Differences occur in some of the analytes from tank to tank.

The Al and NO_3 ratios are about a factor of ten higher than other saltcake tanks such as tanks 241-S-101, 241-S-102, 241-U-102, and 241-U-106. This suggests that there may be a different type of saltcake in the top portion of tank 241-S-109.

The saltcake in tank 241-S-109 is only SMMS1 according to Agnew et al. (1996b).

D3.2 BASIS FOR SLUDGE CALCULATIONS USED IN THIS ENGINEERING EVALUATION

A throughput or concentration factor derived from a similar tank waste (see Section D3.5) was applied. For those analytes that partially precipitated, a partitioning factor was also used as calculated for similar waste (as explained in Section D3.4).

With these two factors and the HDW reported void fraction or porosity (0.686) the total inventory of those analytes that are listed in the R waste stream flowsheets can be calculated.

D3.3 THROUGHPUT OR CONCENTRATION FACTOR

This factor is derived, using Bi values (or another analyte that fully precipitates values), by dividing the total inventory found in the sample analysis by the total inventory calculated using the current tank volume and the molarity found in the original waste stream. This indicates the number of equivalent volumes of solids from the original waste stream that are in the tank. This same factor is used for all analytes that show any precipitation within the tank. If the factor is valid and the analytical data are correct, then inventories predicted by this investigation should be close to those reported in the analytical data where such information exists. Because this factor is associated with the throughput of the tank, individual tanks not connected to other tanks can have different factors. When there are no analytical data for the sludge value, a concentration factor is chosen by using one from the most similar tank available. Caution is noted as this factor may not be correct; however, it is the best estimate available without a sample. The concentration factor used in this evaluation is 10, which is about the average for tanks with a similar sludge such as 241-U-110. The factor in other tanks ranged from 6 to 20, and because no analytical data are available for the sludge layer in this tank, an average CF was used to minimize the error.

D3.4 PARTITIONING FACTOR

Some of the analytes partition between the solids and the liquid layer. The partitioning percent for a given analyte varies based on several factors. Various sources predict some partitioning factors, but good agreement is not often obtained between the sources. It should be noted that when R waste is not the only waste in a tank and the supernates of the wastes mix, each waste can effect the PF of other wastes. To try and determine a more accurate PF for an analyte the following approach was taken:

- A PF for each flowsheet analyte, that partitioned between liquid and solid layers, was determined in a similar tank (241-U-110) as follows:

    - A reasonable prediction as to what percent of the analyte precipitated was made based on past information. Then using the tank volume, other known factors, and the CF a total solids inventory was determined. If for example, a 10 percent partitioning (10 percent to solids) was used and it under predicted the analytical results, the percent was adjusted upward to say 15 percent or 20 percent until the calculated values closely match the analytical data. Usually this matching is accomplished in one or two tries. This PF should then be very close to those used in other tanks of this waste type for that analyte.

    - By using these same factors except for the CF that does not apply and in using the void faction, the liquids inventory of the analyte is determined. The solids and liquids portion is added and compared to the sample analysis.

    - These partitioning percents are then used to predict the inventories in the other R waste tanks. If these percents come close to predicting the sample analytical data for other tanks then these PF must be close to the true factors. This was done for tanks 241-B-202 through B-204 for the 224 waste type and good agreement with analytical data was obtained. It is assumed that this process method will produce similar results from tank to tank for the R waste type.

As this method was used, it was discovered that with some analytes, the original factor matched all tanks as the best factor. In other cases it was found that if the original factor was slightly modified it predicted all tanks better. In the later case the modified factor was used for all tanks. The 241-B-201 through 241-B-204 tanks were the waste tanks in which this was observed (Heasler et al. 1996).

D3.5 SAMPLE CALCULATIONS USED TO PREDICT THE SLUDGE INVENTORY IN THIS ENGINEERING EVALUATION

Components assumed to precipitate (Bi, Al)

Bi: $0.00003\ \text{moles}_{Bi}/L_R \times 13\ \text{kgal}_R \times 3{,}785\ \text{L/kgal} \times 208.98\ \text{g/mole}_{Bi} \times 10\ \text{CF} \times \text{kg}/1\text{E}{+}03\ \text{g} = 3.1\ \text{kg}$

Al: 14,747 kg

Components assumed to remain dissolved in the interstitial liquid (NO_3, SO_4, Na)

NO_3: $4.53\ \text{moles}_{NO3}/L_R \times 0.686_{porosity} \times 3{,}785\ \text{L/kgal} \times 13\ \text{kgal}_{S\text{-}109\ waste} \times 62\ \text{g/mole}_{NO3} \times \text{kg}/1\text{E}{+}03\text{g} = 9{,}481\ \text{kg}$

SO_4: 94 kg

Na: 5,416 kg

Components assumed to partition between aqueous and solid phases (Cr, Fe)

$Cr_{(solids)}$: $0.178\ \text{moles}_{Cr}/L_R \times 13\ \text{kgal}_R \times 3{,}785\ \text{L/kgal} \times 52\ \text{g/mole}_{Cr} \times 10\ (\text{CF}) \times .3\ (\text{PF}) \times \text{kg}/1\text{E}{+}03\ \text{g} = 1366\ \text{kg}$

$Cr_{(interstitial)}$: $0.178\ \text{moles}_{Cr}/L_R \times 0.686_{porosity} \times 3{,}785\ \text{L/kgal} \times 13\ \text{kgal}_{S\text{-}109\ waste} \times 52\ \text{g/mole}_{Cr} \times .7\ (\text{PF}) \times \text{kg}/1\text{E}{+}03\text{g} = 219\ \text{kg}$

Total Cr: 1,585 kg

Fe: used 0.6 as PF for solids and 0.4 as PF for liquids

Total Fe: 222 kg

Estimated component inventories (which include the analytical saltcake and engineering R flowsheet sludge estimates) from this engineering evaluation are compared with sample- and HDW-based inventories for selected components in Table D3-3. Observations regarding these inventories are noted by component in the following text.

Table D3-1. Comparison of Selected Component Inventory Estimates for Tank 241-S-109 Waste.

Component	This evaluation (kg)	Sample-based (kg)	HDW estimated (kg)
Bi	>3	NR	288
K	NR	NR	3350
La	NR	NR	4E-03
NO_3	1.47E+06	1.46E+06	2.29E+05
Mn	NR	54.4	318
SO_4	20,040	19,950	33,000
Cr	5370	3,790	6,810
PO_4	NR	30,900	11,300
F	NR	NR	1450
Al	21069	4,215	97,000
Fe	3,410	3,190	1,170
Na	6.25E+05	6.2E+05	4.67E+05
H_2O (percent)		NR	40.1

Note:

HDW = Hanford Defined Waste
NR = Not reported.

Bismuth. Because the sample-based value was not reported, no meaningful comparison is available to the HDW model. The inventory from the sludge layer was 3.1 kg but no saltcake value is given. The Bi is therefore >3 but probably less than 288, the HDW model estimate.

Nitrate. The HDW estimated inventory is smaller than the sample-based inventory by about six times and the inventory estimated in this evaluation adds less than 1 percent to the sampling results. It is not known why this difference is occurring, but it most likely is because of incorrect feed in information to the model. When no reason for differences is given for other analytes, a model associated problem will be the assumed most likely reason.

Sulfate. The engineering evaluation added the flowsheet sludge prediction to that portion of the sample-based calculations that represents the expected sludge volume. The engineering evaluation was used as the best basis because this portion of the tank was not sampled. It is essentially the same value as the sample predicted. The HDW model predicts about 50 percent more than the other values.

Chromium. The HDW estimated inventory is over 80 percent higher than the sample-based inventory. The estimate from this evaluation is about half way between the other two estimates. The additional amount from the engineering estimate is from flowsheet estimates for Cr in the sludge, which is a much higher molarity than that of the saltcake. The sample-based inventory did not measure the sludge layers of the tank. The engineering estimate was used for the best basis.

Phosphate. The sample-based estimate was used as the best basis because a good prediction of the sludge molarity could not be made from flowsheet information. This estimate is about three times higher than that predicted by the HDW model.

Fluoride. The sample-based estimate was not reported and because a good prediction of the sludge molarity could not be made from flowsheet information, the best basis is that predicted by the HDW model.

Sodium. The engineering estimate is about 1 percent higher than the sample-based estimate because sludge is much lower than saltcake in Na, so little Na was added by the sludge. This engineering estimate was used as the best basis and it is about 35 percent higher than that predicted by the HDW model.

Potassium. There is no sample-based estimate and because a good prediction of the sludge molarity could not be made from flowsheet information, the HDW model estimate becomes the best-basis estimate.

Lanthanum. There is no sample-based estimate and because a good prediction of the sludge molarity could not be made from flowsheet information, the best basis is that predicted by the HDW model.

Manganese. The sample-based estimate was used as the best basis because a good prediction of the sludge molarity could not be made from flowsheet information. This best basis is about six times lower than that predicted by the HDW model.

Aluminum. Like Cr, Al engineering calculations based on the R sludge add significant amounts of analyte to the inventory. The engineering based inventory was used as the best basis and is over five times the sample-based estimate. Because only the upper half of the saltcake was analyzed and similar tanks (241-U-102, 241-S101 and 241-S-102) show twice the Al in the bottom half of the saltcake, the analytical saltcake number was multiplied by 1.5, and was added to the sludge value to give the best basis calculation. The HDW model predicted a value about four and a half times that of this estimate. Although no quality control problems were identified in the sample data, based on Agnew et al. (1996b) and process data from tanks containing similar waste types, the sample-based numbers for Al appear to be low. This is being investigated. The engineering estimate is used as the best basis with a caution that it may be up to four times too high.

Iron. Using the R flowsheet information to estimate Fe in the sludge adds less than 10 percent to the saltcake values from the sample-based value. The HDW model predicts about one third of this value.

D4.0 BEST-BASIS INVENTORY ESTIMATE

Information about chemical, radiological and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage. Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage and other operating data. Not surprisingly, the information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1995). As part of this effort, an evaluation of available chemical information for 241-S-109 was performed, including:

- Data from 1996 partial core samples (Fritts 1996).
- An inventory estimate generated by the HDW model (Agnew et al. 1996b).
- Evaluation of the average R flowsheet

Based on this evaluation, a best-basis inventory was developed (Tables D4-1 and D4-2). In general, the sample-based TCR results were preferred when they were reasonable and consistent with other results. Process estimates were added to the sample-based results for those analytes that appear on the R flowsheet. This was done to add the estimated contribution from the sludge layer, which was a minor component of this tank. Because no sample was available for this layer the engineering assessment must be considered to have a low confidence value. The HDW model was used only where no other data were available.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-109 (11/9/96).

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1,2]	Comment
Al	21,100	E	This value may be as much as 4 times too high.
Bi	288	M	
Ca	245	E	
Cl	937	E	
TIC as CO_3	12,000	E	
Cr	5370	E	
F	1450	M	
Fe	3,410	E	
Hg	42.6	M	
K	3,350	M	
La	4.0E-03	M	
Mn	54.4	E	
Na	6.25E+05	E	
Ni	667	M	
NO_2	11,360	E	This value may be as much as 10 times too low, based on similar tanks.
NO_3	1.47E+06	E	
OH	2.56E+05	M	
Pb	1,480	M	
P as PO_4	30,900	E	
Si	977	E	
S as SO_4	19,950	E	
Sr	8.41E-04	M	
TOC	1,510	E	
U_{TOTAL}	142	E	
Zr	87.2	M	

Notes:

[1]S = Sample-based
M = Hanford Defined Waste model-basededium
E = Engineering assessment-based
NR = Not reported

[2]Sample data were not used because sample recovery was poor and samples were obtained from only the upper portion of the tank (see Appendix B).

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-109 (11/9/96). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1,2]	Comments
^{3}H			
^{14}C			
^{59}Ni			
^{60}Co			
^{63}Ni			
^{79}Se			
^{90}Sr	2.75 E+05	E	Based on calculations from dome space temperatures
^{90}Y			
^{93}Zr			
^{93m}Nb			
^{99}Tc			
^{106}Ru			
^{113m}Cd			
^{125}Sb			
^{126}Sn			
^{129}I			
^{134}Cs			
^{137}Cs	1.06 E+05	E	Based on calculations from dome space temperatures
^{137m}Ba			
^{151}Sm			
^{152}Eu			
^{154}Eu			
^{155}Eu			
^{226}Ra			
^{227}Ac			
^{228}Ra			
^{229}Th			
^{231}Pa			

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-109 (11/9/96). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1,2]	Comments
^{232}Th			
^{232}U			
^{233}U			
^{234}U			
^{235}U			
^{236}U			
^{237}Np			
^{238}Pu			
^{238}U			
^{239}Pu			
^{240}Pu			
^{241}Am			
^{241}Pu			
^{242}Cm			
^{242}Pu			
^{243}Am			
^{243}Cm			
^{244}Cm			

Notes:

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based
NR = Not reported

[2]Sample data were not used because sample recovery was poor and samples were obtained from only the upper portion of the tank (see Appendix B).

Most fields are blank pending receipt of revision to Agnew et al. (1996b), which will include additional radionuclide estimates.

D5.0 APPENDIX D REFERENCES

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996a, *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 East Area*, WHC-SD-WM-TI-614, Rev. 2, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996b, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

Fritts, L. L., 1996, *Tank 241-S-109, Cores 158 and 160, Analytical Results for the Final Report,* WHC-SD-WM-DP-194, Rev. 0, Westinghouse Hanford Company, Richland Washington.

Heasler, P. G., K. M. Remund, J. M. Tingey, D. B. Baird, F. M. Ryan, and J. M. Conner, 1996, *Tank Characterization Report for Single-Shell Tank B-201*, WHC-SD-WM-ER-550, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Hill, J. G. G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

Hodgson K. M., and M. D. LeClair, 1996, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-S-109

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-S-109

Appendix E provides a bibliography of information that supports the characterization of tank 241-S-109. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-S-109 and its respective waste types.

The references in this bibliography are separated into the following three broad categories, and their subgroups.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

- IIa. Sampling of tank 241-S-109
- IIb. Sampling of 242-S Evaporator Streams
- IIc. Sampling of REDOX waste

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

This bibliography is divided into the appropriate sections of material with an annotation at the end of each reference describing the information source. Where possible, a reference is provided for information sources. A majority of the information listed below may be found in the Westinghouse Hanford Company Tank Characterization Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Document contains single-shell tank fill history and primary campaign/waste type information up to 1981.

Jungfleisch, F. M. and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057 Rev. 0-A, Westinghouse Hanford Company, Richland, Washington.

- A model based on process knowledge and radioactive decay estimations for different compositions of process waste streams assembled for total, solution, and solids compositions per tank. Assumptions about waste/waste types and solubility parameters/constraints are also given.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 East Area*, WHC-SD-WM-TI-614, Rev. 2, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document contains spreadsheets depicting all available data on tank additions/transfers.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Document contains single-shell tank fill history and primary campaign/waste type information up to 1981.

Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

- Document shows tank riser locations in relation to tank aerial view as well as a description of riser and its contents.

Lipnicki, J., 1995, *Waste Tank Risers Available for Sampling*, WHC-SD-WM-TI-710, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- Document gives an assessment of riser locations for each tank, however not all tanks are included/completed. Also included is an estimate of what risers are available for sampling.

Id. Sample Planning/Tank Prioritization

Brown, T. M., S. J. Eberlein, J. W. Hunt and T. J. Kunthara, 1996, *Tank Waste Characterization Basis*, WHC-SD-WM-TA-164, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Document that summarizes the technical basis for characterizing the waste in the tanks and assigns a priority number to each tank.

Homi, C. S., 1996, *Tank 241-S-109 Tank Characterization Plan*, WHC-SD-WM-TP-391, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document discusses any and all relevant DQOs and how they will be met for tank 241-S-109.

Field, J. G., 1996, *Tank 241-S-109 Push Mode Core Sampling and Analysis Plan*, WHC-SD-WM-TSAP-087, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains detailed sampling and analysis procedure information for tank 241-S-109 based on applicable DQOs.

Grimes, G. W., 1977, *Hanford Long-Term Defense High-Level Waste Management Program Waste Sampling and Characterization Plan*, RHO-CD-137, Rockwell Hanford Operations, Richland, Washington.

- Early characterization planning document.

Homi, C. S., 1995, *FY 1996 Tank Waste Analysis Plan*, WHC-SD-WM-PLN-101, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains Tri-Party Agreement (see Ecology et al. 1994 listing in Section 5.0) requirement-driven TWRS Characterization Program information and a list of tanks addressed in fiscal year 1996.

Winters, W. I., L. Jensen, L. M. Sasaki, R. L. Weiss, J. F. Keller, A. J. Schmidt, and M. G. Woodruff, 1989, *Waste Characterization Plan for the Hanford Site Single-Shell Tanks*, WHC-EP-0210, Westinghouse Hanford Company, Richland, Washington.

- Early version of characterization planning document.

Ie. Data Quality Objectives (DQO) and Customers of Characterization Data

Cash, R. J., 1996, *Scope Increase of Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, Rev. 2, (internal memorandum 79300-96-029 to S. J. Eberlein, July 12), Westinghouse Hanford Company, Richland, Washington.

- Memo contains interim requirements for the Organic Solvents issue.

Homi, C. S., 1996, *Vapor Sampling and Analysis Plan*, WHC-SD-WM-TP-335, Rev. 2D, Westinghouse Hanford Company, Richland, Washington.

- Vapor sampling and analysis procedure for 200 Area Tanks.

DOE-RL, 1996, *Recommendation 93-5 Implementation Plan*, DOE/RL-94-0001, Rev. 1, U. S. Department of Energy, Richland, Washington.

- Organic solvent issue description in the 93-5 implementation plan.

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- DQO used to determine if tanks are under safe operating conditions.

Kupfer, M. J., W. W. Schultz, G. L. Borsheim, S. J. Eberlein, B. C. Simpson, and J. T. Slankas, 1994, *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology*, WHC-SD-WM-TA-154, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document provides basis for selection of tanks for disposal needs.

Simpson, B. C., and D. J. McCain, 1996, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 1, Westinghouse, Hanford Company, Richland, Washington.

- Document provides data needs for evaluating the LANL model for estimating tank waste compositions.

Slankas, T. J., M. J. Kupfer, and W. W. Schulz, 1995, *Data Needs and Attendant Data Quality Objectives for Tank Waste Pretreatment and Disposal*, WHC-SD-WM-DQO-022, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Documents the needs of the pretreatment function within TWRS.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of tank 241-S-109

Fritts, L. L., 1996, *Tank 241-S-109, Cores 158 and 160, Analytical Results for the 45 Day Report*, WHC-SD-WM-DP-194, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Fritts, L. L., 1996, *Tank 241-S-109, Cores 158 and 160, Analytical Results for the Final Report*, WHC-SD-WM-DP-194, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Documents contain sample analyses from 1996 tank 241-S-109 push core sampling event.

Pool, K. H., B. L. Thomas, J. C. Evans, K. B. Olsen, J. S. Fruchter, K. L. Silvers, 1996, *Tank Vapor Characterization Project: Headspace Vapor Characterization of Hanford Waste Tank 241-S-109: Results from Samples Collected on 6/4/96*, PNNL-11257, UC-606, Pacific Northwest National Laboratory, Richland, Washington.

- Document contains vapor sample results obtained June 4, 1996.

IIb. Sampling of 242 S-Evaporator Waste Streams

- All the information in this section is documented in Process Aids 1970 - 1993. Process Aids is a consecutive compilation of laboratory memos, letters, etc. indexed by year then by subject and/or tank. The following analyses may provide insight as to the composition of the SltCk waste type expected to be in tank 241-S-109.

Jurgensmeier, C. A., 1991, *Results of Single-Shell/Double-Shell Data Research,*" (internal memorandum 28110-PCL91-046 to H. Babad, May 30), Westinghouse Hanford Company, Richland, Washington.

Reynolds, D. A., 1982, *242-S Evaporator Crystallizer Third Partial Neutralization Campaign*, RHO-CD-1515, Rockwell Hanford Operations, Richland, Washington.

Horton, J. E., 1976, *Analysis of Salts from Tank 109-S*, (internal letter 120876 to W. R. Christensen, December 8), Atlantic Richfield Hanford Company, Richland, Washington.

Buckingham, J. S., 1974, *Analysis of Salt Sample from 242-S Evaporator Slurry Receiving Tank 109-S*, (internal memorandum 090374 to N. L. Harms, September 30), Atlantic Richfield Hanford Company, Richland, Washington.

Babad, H., 1974, *Analysis of Solidified Salt Wastes and Associated Mother Liquors*, (internal letter to G. S. Barney, September 5), Atlantic Richfield Hanford Company, Richland, Washington.

Wheeler, R. E., 1974, "*Analysis of Tank Farm Sample: T-4544 109-S*, (internal letter to R. L. Walser, September 16), Atlantic Richfield Hanford Company, Richland, Washington.

Cain, R. J., 1974, *Dry Saltcake Composition*, (Internal Letter to R. E. Vander Cook, October 18, 1974), Atlantic Richfield Hanford Company, Richland, Washington.

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Sant, W. H., 1973, *242-S Feed Samples Number T-9494*, (internal Letter to R. L. Walser, December 18, 1973), Atlantic Richfield Hanford Company, Richland, Washington.

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Puryear, D. A., 1971, *Characterization of S, U, and SX Waste Tanks*," (internal letter to J. O. Skolrud, September 21), Atlantic Richfield Hanford Company, Richland, Washington.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document contains waste type summaries as well as primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions. Purchase record are used to estimate chemical inventories.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory As Of September 30, 1974*, ARH-CD-229, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1994, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 Areas*, WHC-SD-MW-ER-352, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary information from the supporting document as well as in-tank photo collages and the solid composite inventory estimates Rev. 0 and Rev. 0A.

Brevick, C. H., L. A. Gaddis, and W. W. Pickett, 1994, *Supporting Document for the Historical Tank Content Estimate for S Farm*, WHC-SD-WM-ER-323, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendices for the data. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface Level Graph; Appendix F, pg F-1 - Cascade/ Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

IIIb. Compendium of data from other sources physical and chemical

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Vol I & II.*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending August 31, 1996*, WHC-EP-0182-101, Westinghouse Hanford Company, Richland, Washington.

- These documents contain a monthly summary of: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information.

Husa, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Document contains in-tank photos as well as summaries on the tank description, leak detection system, and tank status.

Husa, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document gives assessment of relative dryness between tanks.

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DISTRIBUTION SHEET

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Name	MSIN	Text With All Attach.	Text Only	Attach. / Appendix Only	EDT/ECN Only
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Sandia National Laboratory P.O. Box 5800 MS-0744, Dept. 6404 Albuquerque, NM 87815					
D. Powers		X			
Nuclear Consulting Services Inc. P. O. Box 29151 Columbus, OH 43229-01051					
J. L. Kovach		X			
Chemical Reaction Sub-TAP P.O. Box 271 Lindsborg, KS 67456					
B. C. Hudson		X			
Tank Characterization Panel Senior Technical Consultant Contech 7309 Indian School Road Albuquerque, NM 87110					
J. Arvisu		X			
SAIC 20300 Century Boulevard, Suite 200-B Germantown, MD 20874					
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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
<u>Los Alamos Laboratory</u> CST-14 MS-J586 P. O. Box 1663 Los Alamos, NM 87545					
S. F. Agnew		X			
<u>Los Alamos Technical Associates</u>					
T. T. Tran	B1-44	X			
<u>Ogden Environmental</u> 101 East Wellsian Way Richland, WA 99352					
R. J. Anema		X			
<u>CH2M Hill</u> P. O. Box 91500 Bellevue, WA 98009-2050					
M. McAfee		X			
<u>Tank Advisory Panel</u> 102 Windham Road Oak Ridge, TN 37830					
D. O. Campbell		X			
<u>ONSITE</u>					
<u>Department of Energy - Richland Operations</u>					
J. F. Thompson	S7-54	X			
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G. L. Dunford	A2-34	X			
G. D. Johnson	S7-14	X			
J. E. Meacham	S7-14	X			
<u>Fluor Daniel Northwest</u>					
J. L. Stroup	S3-09	X			
<u>Lockheed Martin Hanford, Corp.</u>					
K. M. Hodgson	H0-34	X			
T. J. Kelley	S7-21	X			
N. W. Kirch	R2-11	X			
L. M. Sasaki	R2-12	X			
B. C. Simpson	R2-12	X			
ERC (Environmental Resource Center)	R1-51	X			
Tank Characterization Resource Center	R2-12	5			
<u>Lockheed Martin Services, Inc.</u>					
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Central Files	A3-88	X			
EDMC	H6-08	X			
<u>Numatec Hanford Corporation</u>					
J. S. Hertzel	H5-61	X			
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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
<u>SGN Eurisys Services Corp.</u>					
D. B. Engelman	L6-37	X			

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